GEOLOGICAL SURVEY OF NEW JERSEY

HENRY B. KÜMMEL, STATE GEOLOGIST

BULLETIN 8

Annual Administrative Report

OF THE

STATE GEOLOGIST

FOR THE YEAR 1912

INCLUDING A SECOND REPORT ON

SHARK RIVER INLET

BY

C. C. VERMEULE, Consulting Engineer

AND

A LIST OF NEW BENCH MARKS

TRENTON, N. J.
MacCrellish & Quigley, State Printers, Opposite Post Office.

1913.

Geological Survey of New Jersey.

BOARD OF MANAGERS.[1]

His Excellency Woodrow Wilson, Governor and *ex officio* President of the Board, ...Trenton.

Members at Large.

John C. Smock,	Trenton,	1913
Alfred A. Woodhull,	Princeton,	1914
Frank Vanderpoel,	Orange,	1914
T. Frank Appleby,	Asbury Park,	1915
David E. Titsworth,	Plainfield,	1916
William Libbey,	Princeton,	1916

Congressional Districts.

I.	Stephen Pfeil,	Camden,	1916
II.	P. Kennedy Reeves,	Bridgeton,	1917
III.	Henry S. Washington,	Locust,	1914
IV.	Washington A. Roebling,	Trenton,	1913
V.	Frederick A. Canfield,	Dover,	1915
VI.	George W. Wheeler,	Hackensack,	1916
VII.			
VIII.			
IX.	E. H. Dutcher,	East Orange,	1914
X.	Herbert M. Lloyd,	Montclair,	1917
XI.	Clarence G. Meeks,	North Bergen,	1915
XII.	Joseph D. Bedle,	Jersey City,	1913

State Geologist,

HENRY B. KÜMMEL.

[1] As of October 31st, 1912.—In April, 1913, Acting Governor Fielder appointed John H. Cannon, of Paterson, and George F. Reeve, of Newark, to fill the vacancies in the VII and VIII Districts.

Letter of Transmittal.

TRENTON, N. J., March 4th, 1913.

Hon. James F. Fielder, Acting Governor and ex-officio President of the Board of Managers of the Geological Survey:

SIR—I have the honor to submit my administrative report summarizing the work of the Geological Survey for the year 1912. This report is made in accordance with Chapter 46 of the Laws of 1912. Several other bulletins on various scientific subjects are nearly ready for publication. These will give in greater detail the results of investigation along certain lines.

Respectfully submitted,

HENRY B. KÜMMEL,

State Geologist.

Administrative Report.

HENRY B. KÜMMEL, *State Geologist.*

Contents.

ADMINISTRATION.

Law and custom demands an annual report from the State Geologist regarding the work under his direction. This report is distinct and apart from the scientific reports which with varying detail set forth the results of the different investigations carried on by the Survey Staff. These results are published as Bulletins and Final Reports and can be obtained upon application to the State Geologist. In the case of a few reports, the remaining copies of which are less than 200, there is a small charge to cover cost of printing and binding.

Expenditures.—The Legislature annually includes in the regular appropriation bill the funds necessary for the work of the Survey. For the fiscal year ending October 3, 1912, the sum of $16,500 was voted. This was later increased by a supplemental appropriation of $2,000, so that there was available for the customary work of the Survey $18,500. In addition to this amount the last Legislature appropriated $500 for salaries and expenses of archæological investigations and the acquistion of archæological material. There was also appropriated in 1911 and 1912 the total sum of $2,250 for borings, surveys and plans for permanent improvement of Shark River Inlet, Monmouth County. The total of all sums available for work during 1912 under the direction of the State Geologist, but subject to an immediate audit by a Committee of the Board, was $21,250. The disbursements may be classified as follows:

EXPENDITURES.

Salaries clerical force,	$1,796 36
" scientific force,	11,164 03
Traveling expenses,	1,568 14
Office furniture,	3 50
" supplies,	213 29
Laboratory equipment,	28 12
" supplies,	322 08
Library,	29 95
Postage,	708 25
Express and freight,	107 31
Telegraph and telephone,	50 89
Engraving and printing maps,	2,460 92
Sundries,	226 13
Unexpended balance, lapsed to State treasury,	2,571 03
	$21,250 00

Unexpended balance is to be apportioned to the various appropriations as follows: General, $2.566; Shark River, $3.90; Archaeology, $1.13. In addition to the above expenditures made from Legislative appropriations, the State Geologist received and disbursed the following sums:

Balance on hand November 1st, 1911,	$63 45
Receipts from sales of maps and reports,	990 64
" " laboratory work,	70 00
" " sale of second-hand property,	1 00
	$1,125 09
Disbursements—Paid State Treasurer,	997 90
Balance on hand October 31st, 1912,	$127 19

Organization.—There were no changes in the membership of the Board of Managers during the year, the following members whose terms expired being all reappointed by the Governor for the new terms ending in 1917:

Harrison Van Duyne, Newark—Member at Large.
P. Kennedy Reeves, Bridgeton—Second Congressional District.
Herbert M. Lloyd, Montclair—Seventh Congressional District.

During the year the Legislature made a new apportionment thereby creating two new Congressional Districts and changing the lines of several old ones. As a result of these changes H. M. Lloyd formerly of the VIIth is shifted to the Xth District; E. H. Dutcher of the VIIIth is now credited to the IXth; J. D. Bedle of the IXth is now in the XIIth; and C. G. Meeks of the Xth represents the new XIth District. There are vacancies in the new VIIth District comprising the county of Passaic except the townships of Pompton and West Milford and in the new VIIIth District, made up of the Eighth, Eleventh and Fifteenth Wards of Newark, Towns of Belleville, Bloomfield and Nutley, in Essex County, and Harrison, Kearny, East Newark, Bayonne and the Seventh Ward of Jersey City.

April first the resignations of Assistants H. M. Poland and S. Percy Jones were received and accepted to take effect the first of May. On August first the resignation of Miss Laura Lee was received and took effect October first.

On May first Henry Jennings, formerly of the Bureau of Soils, U. S. Department of Agriculture, who had been engaged in the Soil Survey work for three years in Northern New Jersey, was engaged to continue his work in soil mapping under the direction of the State Survey. Mr. Jennings had resigned from the Bureau of Soils, and was planning to enter another line of work. The experience which he had gained in three years' work in this State would have made his loss a serious handicap to the work and the Survey was fortunate in being able to retain his services.

Dr. M. W. Twitchell, Professor of Geology at the University of South Carolina and formerly State Geologist of that State, was appointed to the Scientific Staff of the Survey on July first.

He will relieve the State Geologist of some of the routine administrative work of the Survey and will also take an active part in the scientific investigations. Previous to his work in South Carolina, Dr. Twitchell had experience in State Survey work while on the staff of the Maryland Geological Survey.

The vacancy in the office force caused by the resignation of Miss Lee was filled by appointment on September first from the certified list of the Civil Service Commission of Miss Henrietta Kruse.

As in former years most of the men on the Survey rolls are on a per diem basis and are employed only temporarily for specific lines of work. In addition to those mentioned below several employees of C. C. Vermeule, consulting engineer, were engaged on Survey work as in previous years, but under ruling of the Civil Service Commission, these are not regarded as on the Survey Staff.

The following persons were employed during the last fiscal year:

Henry B. Kümmel, State Geologist.
M. W. Twitchell, Geologist.
R. B. Gage, Chemist.
S. Percy Jones, Geologist.
Henry Jennings, Assistant in charge of Soil Mapping.
H. M. Poland, Assistant in charge of Collection of Well Data.
Laura Lee, Clerk and Stenographer.
Henrietta Kruse, Clerk and Stenographer.
John S. Clark, General Assistant.

C. C. Vermeule, Topographer and Consulting Engineer.
R. D. Salisbury, Geologist.
J. Volney Lewis, Geologist.
D. W. Johnson, Geographer.
Ray Pinkle, Assistant on Soil Survey.

Alanson Skinner, Assistant, Archæology Survey.
Max Schrabisch, Assistant, Archæology Survey.

John G. Baumann, Janitor at Laboratory.

Publications.—The new plan of publications of the Survey reports does not seem to be thoroughly understood. Previous to 1909 the Annual Report of the State Geologist for each year included miscellaneous scientific papers. These were of diverse nature and rarely could all of them be of interest to persons

receiving the entire report. This meant more or less waste in distribution, although the publication each year in a single volume of all the scientific reports did bring to the notice of those receiving it, the varied activities of the Survey. It was felt, however, that economy in printing and distribution would be better served by publishing as separate bulletins the various scientific reports. In this way, those requesting specific information could be sent what they wished unencumbered by extraneous matter, while at the same time each report would stand by itself and would not be lost sight of by being bound up with others and included in an "Annual Report." Recognizing, however, that there were a few institutions and persons who for peculiar reasons might properly have all reports, it was arranged to make up a limited number of "Year Books" comprising the bulletins published during the year. Since, however, these are restricted to 100 copies, they are reserved chiefly for libraries. Up to the present time seven bulletins in the new series have been published and their titles are given on page . The publications during the past year were as follows:

New editions of atlas sheets.
Elizabeth, Boonton, Paterson and Jersey City. Scale, 2,000'=1 inch.
Sheets Nos. 24, 25, 28. Scale, 1 mile = 1 inch.

Bulletin 6. The Administrative Report of the State Geologist for the year 1911, by Henry B. Kümmel, State Geologist. Including a Report on Shark River Inlet by C. C. Vermeule, Consulting Engineer, pp. 82 and IV Plates.

Bulletin 7. The Mineral Industry of New Jersey for 1912, by Henry B. Kümmel, State Geologist, pp. 37.

Distribution.—The demand for the maps and reports of the Survey continues with little variation. The topographic maps are sold at the uniform price of twenty-five cents per sheet, which includes postage, while the geologic folios cost from twenty-five to fifty cents, postage extra. No charge is made for the reports of the Survey except in the case of some volumes of which only a few copies remain on hand for distribution. These are sold at cost price. Recipients are requested to pay the cost of transportation of certain of the larger volumes.

The following is a list of the reports which can be obtained only by purchase:

Annual Report for 1883, ...Price, $0 50
Annual Report for 1892, ...Price, 1 55
Annual Report for 1903, ...Price, 40
Annual Report for 1905, ...Price, 55
Paleontology, Vol. I—Braciopoda and Lamellibranchiata of the Raritan Clays and Greensand Marls of New Jersey. To residents of New Jersey, by express charges collect; to non-residents, $1.50, express charges prepaid.
Paleontology, Vol. II—Gasteropoda and Cephalopoda of the Raritan Clays and Greensand Marls of New Jersey. To residents, by express, charges collect; to non-residents, $1.40, express charges prepaid.
Paleontology, Vol. III—Paleozoic Paleontology, ...Price, $1 00
Paleontology, Vol. IV—Cretaceous Paleontology, ...Price, 2 70
Final Reports, Voy. II, Pt. 1—Mineralogy, Botany, bound, price $1.50; unbound, postage 25 cents.
Final Reports, Vol. IV—Report on the Physical Geography of New Jersey, paper cover, price $1.00; bound, price $1.35; photo-relief map, $1.50 extra.
Final Reports, Vol. VI—Report on Clay Industry of New Jersey, bound. $1.60.

The sale of maps by the Survey during the past three years has been as follows:

	Sheets sold		
	1910.	*1911.*	*1912.*
Maps on scale of 1 inch per mile, ...	1485	1491	1718
Maps on scale of 2½ inches per mile, ...	2039	2096	1658
Geologic folios, ...	150	65	69

Several of the bulletins printed late in the previous year were mainly distributed early in the fiscal year covered by this report. In addition Bulletins 6 and 7 were distributed as soon as published and during the year many requests for back reports were received and filled. The total number of reports sent out was 10,856.

Library.—The Survey library continues to increase chiefly by exchange, but to some extent by purchase. It now numbers 1,054 bound volumes, 4,107 unbound volumes and pamphlets and 2,101 maps. During the year the accessions were 48 bound volumes, 164 paper covered volumes and pamphlets, and 65 maps and atlases.

Note Recording.—In the Administrative Report for last year, a new system of note recording was described. This system has been in successful operation during the past year by men engaged in diverse lines of work, as the archæological survey, the soil survey and stratigraphic studies. In all of these lines, this system has been successful in affording an accurate and not too

complicated method of recording the localities exactly. In this system, every locality in the State can be represented by a combination of numbers peculiar to itself. This combination represents, first, the number of atlas sheet, and second, the exact point within the sheet. Each atlas sheet is divided into rectangles measuring 6-minutes of latitude and 6-minutes of longitude. Beginning in the upper left-hand corner, these are numbered across the sheet from 1 to 5, inclusive, number 5 being an incomplete rectangle comprising 2-minutes of longitude at the right. Those on the second row are numbered 10 to 15, those on the third 21 to 25, those on the fourth 31 to 35 and on the fifth 41 to 45. The rectangles numbered 41 to 44, inclusive, differ from the others in comprising 6-minutes of longitude and 4-minutes of latitude. Number 45 embraces 2-minutes of longitude and 4-minutes of latitude. Each of these rectangles is divided into smaller rectangles measuring 2-minutes of latitude and 2-minutes of longitude by lines already engraved upon the sheet. The 2-minute rectangles in each of the 6-minute rectangles are numbered from 1 to 9 beginning in the upper left-hand corner and numbering to the right, number 4 being on the left under number 1. The subdivisions of the incomplete 6-minute rectangles on the right of the sheet, *i. e.*, those numbered 5, 15, 25, 35, are numbered 1, 4, 7, of those at the bottom, *i. e.*, numbers 41, 42, 43, 44, the subdivisions are numbered 1, 2, 3, 4, 5, 6. The subdivisions of the incomplete rectangle in the lower right-hand corner, number 45, are numbered 1, 4. It is evident that by writing first the number of the atlas sheet; second, the number of the 6-minute rectangle; and third, the number of any 2-minute rectangle, we can form a combination of numbers peculiar to any 2-minute rectangle within the State. In order to locate points more accurately each of the 2-minute rectangles is divided into nine equal parts, numbered from 1 to 9, beginning in the upper left-hand corner, and each of these is again divided into nine, numbered similarly. The smallest rectangle represent areas about 330 yards from east to west and 440 yards from north to south. By adding the appropriate numbers of these two smaller divisions to the three already written, it is possible

to get a combination which represents the exact location of any area 330x440 yards. If it is desirable to locate a point still more definitely, a small rectangle representing this area can be drawn in the note-book and a dot inserted in the appropriate place to represent the exact point of observation.

In actual practice, it has not been found necessary to rule upon the field maps any lines subdividing the 2-minute rectangles. The smaller divisions can be more conveniently ruled and numbered on a small piece of tracing cloth or of transparent celluloid which can be laid upon the map in the desired position and from which the smaller numbers can be read. When not in use this is conveniently carried in a pocket in the cover of the note-book. In practice a dot is made on the field map at the point of observation. The number of the atlas sheet of the 6-minute rectangle and of the 2-minute rectangle is entered in the note-book from the map. The transparent guide is laid on the map and fitted to the boundaries of the 2-minute rectangle. Then the numbers of the two smaller divisions are read off.

One advantage of a definite system of this character is that it permits anyone reading a survey report in which in addition to a general description of a locality, its exact position is given by this system, can fix it on any survey atlas sheet for himself if he so desires. Specimens labeled with this number can always be referred to their original source, even if the original field map be not at hand. Cumbersome descripitions of localities are also avoided.

Survey quarters inadequate.—The crowded condition of the quarters available for the work of the survey is such as to interfere very seriously with the efficiency of its workers. There is one room measuring 19 by 15 feet which is shared with the Forest Commission of which the State Geologist is Executive Officer. In this are five desks, table, filing cases and four clerks. Not a single article of furniture can be spared and there is barely room to properly transact the routine business. Callers waiting an opportunity to consult the State Geologist or the Forester are compelled to stand for lack of room. The only other office room measures 13 by 14 feet and serves as the private office of the State

Geologist and the department library. It contains 66 unit book-cases (11 vertical rows), a filing case, desk, and a drafting table which now has to be used as a desk for Dr. Twitchell. He is constantly interrupted in his work by the conversation of callers to see the State Geologist and by the transaction of routine work. There is no room for sorting out material collected in the field so that it can be studied nor for the preparation or proof-reading of maps, etc. It has been necessary to arrange for one field man to work to the State Experiment Station at New Brunswick during the winter, largely through lack of room at the capitol.

In addition to the meager office room described, the Survey has a small fireproof vault in another portion of the State House and several storage and shipping rooms in the basement. The latter are fairly adequate for their needs but of course cannot be used as rooms for scientific investigations.

For several years it has been necessary to maintain a chemical laboratory in connection with the Geological Survey. The work in this department is constantly growing, very largely because of the co-operative work which the Survey has been asked to undertake in behalf of other departments of the State. In addition to the chemical work incidental to the investigations of the Survey, a great deal of work is constantly being done in the way of testing oils and bitumens used in the construction of State-aided improved roads. This work is largely physical rather than chemical and cannot be carried on in the same room and with the same apparatus as is used in chemical determinations. Every year there has been urgent need for the testing of more road materials and wider experimentation along these lines. This work must be carried on if the State is to build properly certain classes of roads and apparatus and quarters must be provided for the work. The loss which may ensue to the State under a single contract from the use of improper material may exceed the entire cost of a properly equipped laboratory.

For the past nine years the Survey has occupied, free of charge, the second story of a brick building belonging to Col. W. A. Roebling, a member of the Board of Managers. While the best that could be obtained under the circumstances it was not

planned for a chemical laboratory and all work which has been done there has been carried out at considerable inconvenience.

The rooms occupied are as follows:

Analytical Room.—Dimensions 12 by 13 feet, two windows, north exposure. This room contains hoods, sink, water still, table for work, drawers, etc. It is the only room except the toilet with running water and sewer connections. Two closets opening off this room are 4 by 5 feet which are used for storing glassware and chemicals.

Grinding Room.—Dimensions 8 by 8 feet, one window, western exposure. This room contains three pieces of machinery and an electric motor for crushing and grinding rock samples and fro separating bitumen. In order to install this machinery, it was necessary to set it up in the toilet room.

Oil Testing Room.—Dimensions 10 by 10½ feet, with a small closet 2 by 8 feet, two windows, north exposure. This room contains gas ovens, water baths, cupboard for storing small apparatus. It is used chiefly in the testing of oil and bitumens but is not sufficiently large to accommodate all the apparatus used in this work.

Weighing Room.—Dimensions 10½ by 15 feet, four windows, south and west exposure. This room contains the working library of chemical books, analytical balances, and numerous bitumen-testing machines.

Office and Record Room.—Dimensions 10 by 16 feet, with closet 5 by 4 feet, two windows, south exposure. This room contains a filing cabinet, desks for chemist and assistant, typewriter, table for microscope, etc.

Store Room.—In connection with the work of the laboratory, it is necessary to store for considerable periods large numbers of samples of materials, awaiting examination or kept for future references in case the accuracy of the determinations should be questioned. This is particularly true in the case of road materials, where, under some contracts, the successful bidder is required to file samples of the materials to be used. These have to be kept for comparison with samples of the materials actually used in the road, until the work is completed and the road ac-

cepted. A large store room, readily accessible, is therefore necessary. The room at the present laboratory available for this purpose is in the air chamber between the ceiling and the roof. It is reached by a vertical ladder through a narrow trap door and a more inconvenient place to store samples can hardly be imagined.

So crowded are the present laboratory quarters that it is impossible to install several pieces of machinery of which there is urgent need for certain lines of work. The time has certainly come when the State should make adequate provision either by the erection of a special building for the office and laboratory of the Geological Survey alone, or preferably by the construction of a large building specially designed to house all scientific departments of the State Government. Until larger quarters are provided, the work of the Survey will continue to be done under conditions which very greatly reduce the efficiency of its workers.

TOPOGRAPHIC AND ENGINEERING WORK.

Mr. C. C. Vermeule has continued in charge of the Topographic and Engineering work of the Survey. In this he has been chiefly assisted by Mr. P. D. Staats.

Bench Marks.—During the summer of 1911, in connection with studies of the stability of the New Jersey coast, it was apparent that many of the old bench marks established during the original Topographical Survey between 1877 and 1887 have been obliterated. Owing to the extreme economy with which this earlier work of the Survey was done, an economy so rigid that the total cost of the field work and the preparation of manuscript maps on a scale of three inches to a mile amounted to only $6.93 per square mile (exclusive of some triangulation by the U. S. C. & G. S.), it was not possible to establish as many permanent bench marks as would have been desirable. A large number of secondary elevations were listed in the Report on Topography, but it was found that these lists were fast losing their value owing to the disappearance of these marks. Accordingly, last March, the Legislature was requested to grant an increase in the Survey

appropriation to permit the running of new lines of levels and the establishment of new bench marks. This increase was granted and in the autumn two parties were placed in the field. Mr. Vermeule has submitted the following report of their operations:

NEW YORK, November 27th, 1912.

Dr. H. B. Kümmel, State Geologist, Trenton, N. J.:

DEAR SIR—I send herewith a report of the leveling operations from September 16th to October 31st, inclusive. During this period there were two leveling parties in the field.

Mr. Jeffrey R. Hosking started at Paterson, including the bench marks on the Morris Canal at Centreville and Richfield, and worked westward along the line of the Delaware, Lackawanna and Western Railroad to Phillipsburg and Easton. He also made a branch run to Morristown, examining all of the original bench marks of the Survey, so far as they could be found, and verifying their elevations. He also stablished a considerable number of new bench marks. The statistics of his work are as follows:

Number of miles run once,	83
Number of miles repeated,	39
Old marks re-established,	31
Old marks missing,	25
New bench marks established,	93

You will note that during 40 working days, of which 4 were lost by storm, 36 days being actually employed in leveling, this party leveled 122 miles, or an average of 3.4 miles per day.

Mr. Staats operated in Hudson, Bergen and Passaic counties, and also in Newark and Bloomfield, Essex County. His operations were generally similar to Mr. Hosking's, including the examination and verification of the original bench marks and the establishment of new bench marks. The statistics of his work are as follows:

Number of miles run once,	89.6
Number of miles repeated,	15.4
Old marks re-established,	32
Old marks missing,	17
New bench marks established,	86

The rate of leveling was for this party 2.92 miles per day. It should be stated that much time was necessarily consumed in preliminary examinations of the old bench marks and in looking up sites for new bench marks. Mr. Staats, in his territory, was often delayed considerably in getting permission to place bench marks on public and private buildings. In neither case was anything like all of the time employed in the actual running of levels, and bearing this in mind, the running of a total of 227 miles of levels by the two parties during 36 working days, averaging almost exactly 3 miles a day, per party, must be considered a very satisfactory rate of progress.

You will observe that the two parties together established 179 new bench marks in the place of 42 old bench marks lost; consequently, where we had formerly 105 bench marks in all, we have, as the result of the work during the period covered, 242, showing a substantial increase in the number of bench marks. You will also observe that about 40% of the old bench marks are missing.

The cost of the foregoing work was $1,253.38, being at the rate of $5.52 per mile for 227 miles of levels run, or at the rate of $5.18 per bench mark for 242 resulting bench marks.

Respectfully submitted,

C. C. VERMEULE.

Since the leveling parties were already organized and at work, it was decided to continue the field work into the new fiscal year as long as weather permitted. The parties remained in the field through November and the early part of December. In the list of bench marks, which they have established, given on p. 58, no distinction is made between those located before the first of November and those in the present fiscal year. The latter, though strictly belonging to next year's report, are there included, in order that the data may be made public at the earliest possible moment.

Revision of Sheet 37.—In accordance with the policy of the Survey to engrave from time to time copper plates to replace the worn-out lithographic stones of the atlas sheets, work has been started on sheet 37, comprising chiefly Cape May County. As a preliminary, the culture was corrected in the field in order to incorporate the many changes which have occurred since the original survey. In the belt between the main shore road and the ocean, these changes were so extensive that it was necessary to make entirely new drawings for the engraver. For the remainder of the sheet, the additional corrections will be made upon photographs reduced from the original mother map made in 1884. An entirely new projection on a scale of one inch to the mile has been laid down for the use of the engraver with measurements carefully marked in order to secure accurate control of the engraving. The route of the Inland Waterway will be shown on the revised map as well as the extensive improvements at Cold Spring Inlet, the new harbor at Cape May and the new railroad to Wildwood.

Improvement of Shark River Inlet.—An act of the Legislature approved May 1, 1911, appropriated the sum of $1,000 and directed the Board of Managers of the Geological Survey to employ an engineer to make a survey of the mouth of Shark River and to draw plans and make estimates of the expense of making a permanent inlet thereto. In accordance with this action the Board of Managers appointed a Committee, consisting of Messrs. Harrison Van Duyne, Clarence G. Meeks and T. Frank Appleby

to employ an engineer and carry out this work. Mr. Vermeule, Consulting Engineer of the Survey, was requested to make these plans and estimates and a preliminary report was submitted to the Board under date of February 5, 1912, in time to be published as an appendix to the Administrative Report of the State Geologist for 1911, although its preparation was a part of the work of the present fiscal year. Only a portion of the appropriation was used in the preparation of this preliminary report, but the balance was inadequate to make the necessary borings and to carry the work to a point which would enable the engineer to prepare the final plans and specifications. The report as submitted by the Engineer was transmitted to the Governor, under date of February 14, 1912, with the recommendation that "If the improvement of Shark River Inlet be deemed by the Legislature to be of public importance, the Board of Managers of the Geological Survey recommends that this plan be adopted."

A further appropriation of $1,250 was made in the supplemental appropriation bill, approved April 3, 1912, for completing the survey. This was done and the final report and specifications, under date of October 21, were presented by the Engineer.

The Legislature also appropriated the sum of $35,000 for the purpose of making a permanent inlet at Shark River, the work to be done under the management and supervision of the Board of Managers of the Geological Survey. This appropriation, however, was conditioned upon the municipalities adjacent to Shark River raising and placing at the disposal of the Treasurer of the State of New Jersey the sum of at least $20,000 to be used in conjunction with that appropriated by the State. The required amount was promptly appropriated by the municipalities involved and soon after the close of the fiscal year, a portion of it was paid into the State Treasury. At its meeting, December 3, 1912, the Board of Managers accepted the report of the committee and the accompanying final plans and specifications of the Engineer and directed the State Geologist to advertise for bids as soon as the terms of the law regarding the improvement had been fully complied with by the municipalities. The report of the commit-

tee, the action of the Board and the final plans and specifications of the Engineer are fully set forth on pp. 38–53 of this report.[1]

GEOLOGIC WORK.

Report on the Pleistocene Formations of Southern New Jersey.—The manuscript of a report upon the Pleistocene Formations of Southern New Jersey, by Prof. R. D. Salisbury, has been received for publication. This report summarizes the results of field studies commenced in 1892 by Mr. Salisbury and his assistants, chiefly, G. N. Knapp, and continued at intervals until 1905. Reports of progress were made in a number of Annual Reports of the State Geologist, notably those of 1892, 1893, 1894, 1895, 1896 and 1900. Much additional field work in the way of revision of mapping and study of alternative hypotheses was done subsequent to 1900, but further publication of results in the Survey reports was reserved until the final report should be prepared. This has been considerably delayed, chiefly because of the very brief period each year that Mr. Salisbury could spare from his many other duties for this work. In the interval, however, descriptions of Pleistocene deposits have been prepared and published as part of the text of the Philadelphia and Trenton Geologic Folios issued in co-operation with the U. S. Geological Survey.

The final report now in manuscript will be published as soon as the State Printing Board authorizes its printing.

Shark River Marl.—Through the researches of Cook, Clark, W. B., and Knapp, the areal distribution and lithologic features of the Eocene of New Jersey are already fairly well known. Whitfield, supplementing the earlier studies of Conrad, Gabb and others, describe the Eocene fauna in detail and Clark, Harris and Vaughan have discussed the correlation of New Jersey Eocene with that of other regions. Since, however, the earlier workers differ somewhat in their mapping of its areal extent and diverse views are held regarding the very interesting question of the re-

[1] Since writing the above, bids were received on Feb. 27th, and rejected because they exceeded the amount available for the work. The Legislature made an additional appropriation early in April and the plans were slightly modified so as to reduce the cost. New bids are to be received May 8th.

lation which the New Jersey Eocene bears to that of other regions, more particularly that of Maryland and Virginia, it has been thought desirable to reinvestigate the New Jersey deposits, and the fossils obtained from them. The degree of the diversity of opinion as to the proper correlation of the New Jersey Eocene is shown by the fact that Clark regarded it as older than that of Maryland and Virginia; Harris, according to Dall, regarded it as younger, while Vaughan is inclined to think it is younger than "The Aquia Creek beds of the Pamunkey" of Maryland. In view of these different conclusions the investigation was begun and at the request of Dr. M. W. Twitchell was assigned to him. He commenced field work in September.

Careful examination was made of the ocean bluff near Deal Beach, the several arms and adjacent ravines of Deal Lake, the main stream and branches of Shark River near Hamilton, the main stream and branches of the Manasquan River near Farmingdale and the Metedeconk River near Bennett's Mills, and detailed study made of every exposure. At least fifteen good sections of the Shark River Marl, the only Eocene formation in New Jersey, were found, six near Deal Lake, three along Shark River and six along Manasquan River. Fossils were collected at nearly every one and these collections constitute a valuable addition to the materials already in the State Museum, as their exact geographic and stratigraphic position is known, and the relative abundance and value as index fossils of certain species can be in large measure determined from them. The fossils were casts and, as the matrix became pulverulent on drying, had to be promptly treated with melted paraffin to preserve them.

A start has been made upon the study of the fossils collected; but this work has not yet proceeded far enough to justify any final statement at the present time. It may be said, however, that as the result of his investigating, Dr. Twitchell has fixed more definitely than before the areal extent of the Shark River Marl, at present actually exposed or covered only by post-Miocene formations and has made some corrections in the maps of previous workers. He has determined the uppermost exposed layer of the New Jersey Eocene to be a light-green non-glauconitic sandy

clay, carrying fossils, and passing gradually downward through layers intermediate in character to the typical dark bluish-green, mottled, highly glauconitic layer known as the Shark River Marl. The so-called "indurated layer" at the top of the Shark River Marl is not a distinct stratigraphic layer, but an induration of whatever portion of the bed happens to be nearer the surface, and therefore to have lost some of its moisture. He has also discovered fossils in the "Ash Marl" of Cook, *i. e.*, the upper layer of the Manasquan formation. The fossils are not very abundant and consist chiefly of casts of poor quality; but they may enable us to determine whether the "Ash Marl" is Cretaceous, as hitherto held, or Eocene. If it proves to be Eocene then the areal extent of the Eocene formations of the State will be somewhat enlarged.

Mineral Production.—Early in the year the statistics of the mineral production of the State for 1911 were collected by co-operation with the U. S. Geological Survey and were published as Bulletin 7, issued in June. The total value of the mineral industry for 1911 amounted to $37,716,411, a substantial increase over the figures for 1910. This is equivalent to an average of $4,585 per square mile of territory and $15 per capita of population, on the basis of the last census. It is evident that New Jersey has maintained its high rank in the value of her mineral productions per square of territory.

The lists of producers comprise approximately 700 names from practically all of whom some reply is received. Those who do not answer at first, second or third requests for information are favored with a registered delivery letter, a telegraph request, a long-distance telephone call, and finally, if all else fails, and the matter is of importance, with a personal call from an assistant. A few producers, by their neglect to return the inquiry cards properly filled out, delay very much the completion of the work and at the same time increase the expense. Co-operation with the National Survey has reduced the expense of this work, since all correspondence in this line is done under frank and the necessary blanks are furnished by the U. S. G. S.

Well Records and Underground Water Supplies.—The question of underground water supplies continues to be one of great interest to many citizens of the State and the Survey receives frequent requests for information and advice. These come both from individuals, municipal officers, and from State Boards. In every case all the information available is freely imparted, even though it may necessitate considerable investigation by some one of the Survey staff to get at the pertinent facts. During the year the State Geologist has been consulted by the authorities of the State Prison at Trenton and by the Fish and Game Commission, by Borough and County authorities and by individuals. In many cases this office is not advised of the final results, so that the State Geologist does not always know whether the information given has been of assistance or not, or whether his suggestions have been followed.

In view of the wide application of much that is contained in some of these replies, they may be of general interest and several of them are here included.

Endeavors to obtain water in the granites, gneiss or trap rock of Northern New Jersey frequently are unsuccessful or only partially successful. The Saddle River Oil Co. drilled along the Pequannock River 3 miles above Butler, and penetrated first glacial drift 125 feet, then hard granite gneiss to 406 feet. A little water was obtained at 80 feet in drift, and some in rock at 198 feet. The company wrote asking for the depth at which water might be found *under* the granite gneiss. Inquiry was not made until after drilling over 400 feet. The following reply was sent:

TRENTON, N. J., Sept. 9th, 1912.

Mr. C. J. Skidmore, Saddle River Oil Co., 26 Broadway, New York City:

DEAR SIR—I have your letter of September 7th in reference to a well you are drilling below the Newark Water Company's intake on Pequannock River. If you have not obtained the amount of water you need, I cannot advise you to go any deeper. In fact I should advise you not to because I believe your chances of obtaining water are steadily diminishing. It has been found as a result of drilling several hundred wells in the granite and gneiss rocks of Connecticut and New Jersey that the chances of obtaining water decrease below 250 to 300 feet.

There is no possibility of penetrating the rocks you are in as they represent the very foundations of our geologic system. Of course with deeper drilling you may find slight variation in the texture of the rocks, and there is a remote possibility that your drill would intersect a water-bearing fissure, but the chances of this are diminishing with every foot of increased depth, and I should not advise further drilling.

Before abandoning the well you might find it advantageous to shoot it with dynamite at about the depth at which water was found in the rock.

Yours truly,

HENRY B. KÜMMEL,
State Geologist.

A somewhat similar case was that of the State Prison, Trenton. No attempt was made to utilize the information on file in this department until after the work was commenced and a dry hole 300 feet deep obtained. Later in response to a request for information the following letter was sent the Supervisor:

TRENTON, N. J., March 5th, 1912.

Mr. Samuel W. Kirkbride, Supervisor, State Prison, Trenton, N. J.:

DEAR SIR—In response to your request I am pleased to put in writing substantially what I told you and the other gentlemen in your office this morning regarding the possibility of obtaining water on the State Prison grounds.

The data at hand show that these grounds are underlain at a depth of about 40 feet by crystalline rock, which we may refer to in general as granite or granite gneiss. These rocks are extremely dense, the pore space in them being considerably less than 1 per cent. That is, a mass of this rock without cracks would absorb through its microscopic pores less than 1 per cent. of its volume of water. The denseness of this rock as compared with some porous sandstones is shown by the fact that the latter absorb as high as 25 per cent. of their volume. This being the case, the only water which can be expected in this formation is contained in cracks and crevices which traverse it and which lead downward from the surface or intersect other cracks which communicate with the surface. Whatever water exists in the rocks has beyond all question fallen as rain water in comparatively close vicinity to the wells, and, after percolating through the overlying stratum of more or less clayey gravel, found its way into these cracks.

A large part of Connecticut is underlain by rocks of similar character to that at the State Prison, and the results of 300 borings are on record. The yield varied from nothing to 200 gallons per minute, the average being about 15 gallons. Only three wells were reported as yielding more than 100 gallons per minute, and eight wells 60 to 100 gallons per minute, although the yield of several others is reported as "good," large" or "very large." About 10 per cent. yielded less than 2 gallons per minute.

In New Jersey very similar results have been obtained. Of twelve wells drilled in gneiss and granite near Bernardsville, the average yield was only 15 gallons per minute, although one well was reported to give 100 gallons per minute.

You will note, therefore, from the above that it is not often that large yields of water can be expected from this formation.

The Connecticut wells range from 15 to 845 feet in depth. The deepest of those in New Jersey, in this formation of which I have record, are a little over 700 feet. Experience has shown that the most ample supplies are usually (though not exclusively) found within 250 feet of the surface. Below that depth the chances of obtaining water decrease. Since the cost of drilling also increases with depth, it is usually better not to continue a boring in this rock below 250 or 300 feet. If water has not been obtained within that depth, it is usually better to try another hole elsewhere than to continue the old one.

Experience has shown that it is sometimes possible to increase the yield in wells of this character by shooting them. This shatters the rock in the vicinity of the well and increases the possibility that streams of water in cracks adjacent to the boring will be tapped.

I, therefore, recommend that, if you are advised by men who have had experience in shooting wells, that your well can be shot without danger to

the neighboring buildings, it be done, as I understand that at a depth of 300 feet it is practically dry.

I might add that there is no probability whatsoever that by deeper drilling you will reach a geologic formation materially different from that in which the well is now located. Minor variations in texture, color and hardness of the rock may be expected, but I know of no reason which would warrant me in expressing the belief that a water-bearing stratum can be reached by deeper boring. There is, of course, a possibility that at a greater depth the boring would intersect a fissure or shattered zone in the 1ock through which considerable water might be obtained. On the other hand, the greater the depth the greater the pressure and the more the tendency to close all joints and cracks by the mere weight of the overlying rock.

Yours truly,

HENRY B. KÜMMEL,
State Geologist.

In response to a request regarding ground water conditions near Stanhope, the following letter was written:

TRENTON, N. J., Fbruary 10th, 1912.

Dr. D. A. Feddle, 378 Ninth St., Brooklyn, N. Y.:

DEAR SIR—In reply, to yours of recent date regarding water near Stanhope, N. J., I would state that I cannot give you any very definite information without making a personal inspection of the ground. All the underlying rock in that region is a very dense, hard crystalline rock, technically a granite gneiss. This rock is practically impervious to water, except as it is traversed by numerous joints and cracks. In some places these are so numerous that a well 200 or 300 feet deep intercepts a sufficiently large number to obtain a moderate supply. Yields of 25 gallons per minute are rather the exception than the rule. In most cases the yield is less.

The gneiss rock is overlaid to a greater or less thickness by a mantle of glacial drift. This varies from sand and gravel to a tough, stony and bowldery clay. Locally it is so thin that the underlying rock is within a few feet of the surface, or, in fact, appears at the surface. In other places, not necessarily very remote, the drift may attain depths of 100 feet or more. Where it attains considerable thickness, and is an open texture, the best chances of obtaining water are in its lower portion, inasmuch as the ground water would tend to accumulate in the basal portion of the drift just above the relatively impervious rock.

If the rock outcrops on your property or in the close vicinity, the chances are that it does not lie very deep where you will have to drill. If, however, there is any reason to believe that the rock lies deep, the chances of obtaining water in the drift are very much better.

If you drill, I would not recommend that you penetrate the bed rock for any great distance, provided it is covered by a considerable thickness of drift, for if you do not obtain the water you need in the drift there is even less chance of your getting it in the rock. If, on the other hand, the rock lies very close to the surface, it may be worth while to drill not to exceed 250 feet in the granite gneiss.

Yours truly,

HENRY B. KÜMMEL,
State Geologist.

The Empire Steel and Iron Company, desiring to supplement their water supply for use in the furnace and power plants at Oxford Furnace, wrote the Survey for information before spending money in drilling. The reply sent was as follows:

TRENTON, N. J., May 31st, 1912.

Mr. J. S. Stillman, Empire Steel and Iron Co., Catasauqua, Pa.:

DEAR SIR—I have your letter of May 28th in reference to a boring at Oxford, with a view to increasing your water supply. The mines at Oxford will give you the best information you can get regarding the possibility, or probability, of obtaining an adequate supply of water in the crystalline rocks at Oxford. I do not know whether your mines there are very wet or not. The amount of water you could expect to obtain from a well sunk in the crystalline rocks on the sides of the valley would bear about the same proportion to the amount you have in your mines as an 8-inch hole has to the area of the mines. It is, of course, possible that the 8-inch hole might strike a fissure containing a very considerable quantity of water, and so yield proportionately more. But, on the other hand, it is equally possible that the hole might penetrate for its whole length comparatively dry rock.

In the bottom of the valley the bed rock is somewhat deeply buried beneath the unconsolidated deposits of clay, gravel and muck. Along the railroad track, about one-quarter of a mile north of the station, there is an outcrop of a limy sandstone which rests upon the crystalline rock, and which in other portions of the State always underlies the blue limestone. Its occurrence here has been interpreted to mean that a tongue of limestone extends up the valley from the northeast perhaps as far as the furnace. If the unconsolidated deposits on top of the rock are of considerable thickness, as seems to be the case from the absence of any rock exposures, I think there is a pretty good chance of your getting the supply of water in the valley. If the basal beds of this unconsolidated material are coarse gravels, your chances are much increased, as the rock below would form an impervious layer, holding the water in the gravel. I doubt whether you would obtain a great supply of water in the rock, if you do not find it in the layers above the rock. Your best chance of obtaining water is along the central line of the valley, as the ground water from the sides of the valley would tend to concentrate along this line. * * *

Yours truly,

HENRY B. KÜMMEL,
State Geologist.

It will be noted that the essential points in these four letters are the following: 1. Granite and gneiss rock have so dense a structure that they contain practically no water in pore spaces. The only water in these formations is contained in the cracks and crevices by which they are traversed. 2. Experience has demonstrated that the chances of obtaining adequate supplies are best in the upper 250 feet of these rocks, and they decrease with greater depths. 3. There is absolutely no basis for the hope that it may be possible to drill through this formation and reach other strata beneath. 4. While there is a remote possibility that a large open fracture carrying much water may be found at depths greater than 300 feet, the probability is extremely remote and does not warrant the necessary expenditure. These conclusions are of wide application—since they hold true for all of New Jersey underlain by granite or gneiss rock. Except No. 3 they are also true for all territory underlain by trap rock.

A request for information regarding the possibilities of obtaining a flowing well at the State Game farm at Forked River was received from the Fish and Game Commission. A good supply of water at about 180 feet had been obtained, but it rose only within 4 feet of the surface and did not overflow. A flowing well was desired to furnish water for the bird pens, animal paddocks, etc., without the cost of pumping. The data at hand regarding deep-water horizons at that locality were meager, but such as they were, it seemed probable that there were two chances in three of obtaining a flowing well at a depth of 400-450 feet. Subsequent drilling showed that this estimate was somewhat in error, the water-bearing stratum being reached at 509 feet. The pressure, however, was sufficient to raise the water several feet above the surface and at a height of 2 feet above the surface give a moderate flow.

Before leaving this subject, the State Geologist wishes to emphasize the importance of sending to this office complete records of all new wells drilled. These should include the following facts: Location, elevation and name of owner; record of strata passed through, depths at which water was struck, height water rose in pipes, yield on pumping test, amount water was lowered by pumping test. More and more, property owners and well drillers are availing themselves of the data on file in the office of the State Geologist and are applying for information. It must be remembered that he is able to answer questions of this nature chiefly because of the records on file. The more complete these records, the more accurate and detailed the information available. The hearty co-operation of all well drillers and property owners who have wells drilled is therefore strongly urged.

CHEMICAL LABORATORY.

The work in the laboratory has continued in charge of Mr. R. B. Gage, who has been assisted by Fred Baumann. In substance, Mr. Gage's report of the operations there during the past year is as follows:

The major part of the work has consisted in making analyses of soil samples collected in the progress of soil survey investiga-

tions and of asphalts, oils, paving mixtures and pavement samples for the State Road Commissioner. These two lines of work are carried along together, so that it is hardly possible to state how much time has been given to each. It is approximately shown by the numbers of samples of the different materials which have been analyzed, but this method is not entirely satisfactory since some materials naturally require much more time for analysis than others.

Soils.—Sixty-three complete analyses of soil samples have been made and eighty-six other analyses have been checked up for the determination of certain elements. In some only one or two determinations are thus checked, while in others several are made, if, for any reason, the first analysis is found to be questionable. Owing to the inadequate facilities, these analyses represent the expenditure of much more time than their numbers would indicate, for it is impossible under present conditions to work on certain determinations while others are being made. It has, therefore, frequently been necessary to suspend all other kinds of work when determinations of this character are made.

During the year considerable new apparatus has been installed which will greatly facilitate the work and increase its accuracy. In order to place some of this, the laboratory had to be partly remodeled. Considerable time was consumed in making these changes, during which very little scientific work could be done.

In addition to the analyses of the soil, several samples of water have been tested and preparations were made for testing samples of coal purchased by State institutions under contracts based on the heat-producing qualities of the coal. No samples of coal were tested during the last fiscal year, but determinations made since demonstrate quite conclusively the necessity of these tests if coal of proper quality is to be obtained.

Oils, asphalts and pavement samples.—Tests of these materials have been made at the request of the State Road Commissioner in accordance with the plan of co-operation existing between the two departments. The greater part of the expense of this work has been paid by the Road Department. Much more work in this line has been done during the past year than ever before.

An endeavor has been made to test each shipment of asphalt used on all roads to the cost of which the State made any contribution. This necessitated testing over 200 samples of asphalt and about 75 samples of oil. In addition to the examination of these bitumens over 100 samples of pavements, paving sands and stone were tested.

In order to protect the State thoroughly in the construction of bituminous pavements, samples of the pavément should be taken each day during construction, in order to determine that the required amount of bitumen and the proper grade and quality of road metal have been used and also that the pavement is of the proper composition. With the force of men and laboratory equipment available, it was impossible to do this for all pavements laid during the past summer. Additional apparatus has now been secured, and it is hoped that with the employment of another assistant these tests can be made in another season. With an additional helper, one chemist can handle the soil and another the asphalt work exclusively so that more and better results can be accomplished.

Miscellaneous work.—A small number of miscellaneous determinations have been made in addition to those on the subjects specified above. For some of this work a charge has been made and the receipts paid into the State Treasury. The Chemist of the Survey is frequently called upon to make determination of various sorts for other members of the Survey—determinations related to their specific lines of investigation. These are of such a miscellaneous character that only a general report regarding them can be made.

Importance of work.—There is every prospect that in the near future this department will be called upon to do more testing of road materials than ever before. The analyses of soils in connection with the soil survey should also be carried on more rapidly. Conditions in the laboratory get worse as the volume of work increases. Every square foot of available space is now being used. The ventilation has never been satisfactory, and with the increased amount of work done the fumes rising from the work become more concentrated. At times it has

been necessary to stop all work, open the windows no matter what the outside temperature, and leave the building until the atmosphere had cleared. The necessity for larger and better-equipped quarters for this important branch of the Survey has already been set forth in previous pages of this report. The importance of the work which the Survey is doing for the State Road Department is indicated by the following quotations from a letter recently received from Col. E. A. Stevens, the Road Commissioner:

TRENTON, N. J., December 5th, 1912.

Dr. H. B. Kümmel, State Geologist, Trenton, New Jersey:

MY DEAR DR. KÜMMEL—Referring to your verbal inquiry as to the necessity for the work now being done by the Chemist of the Geological Survey for this department, I would say that there can be no question as to the importance and necessity of these services. Our most expensive types of roads require the use of bitumen, and, in some cases, Portland Cement in quite large quantities. Of the former materials there are on the market a very large number, many of which are not suited to our use, and many others suited only to special types of construction. The competition between the sellers is very keen and the salesmen often induce the local bodies to request the use of an entirely unsuitable material for a certain specific job. The Chemist of the Geological Survey has had special training in hydro-carbon chemistry. Such a training is comparatively rare, there being but few consulting chemists who could very well advise the department. We will either have to dispense with the service entirely and trust to luck in buying our materials or have to depend upon the services of consulting chemists. Such services would be much more expensive to the State, and the department could probably not rely upon the prompt examination of specimens submitted, which promptness is absolutely essential to anything like efficiency in the work of contracts. The risk to which I have above alluded is increased by the fact that brands of good material may be prepared for an entirely different use from that intended, which fact requires careful and expert examination to detect.

* * * * * * * In order to be assured of receiving the quality of materials and work specified, it is necessary, especially in bituminous work, to have samples. These we have absolutely no room to file in the rooms set aside to the department in the State House, and Mr. Gage is now taking care of them in the laboratory, I fancy, at considerable inconvenience to himself and some detriment to his work. At the same time the samples must be preserved, and there is no other place where we can find room for them.
* * * * * * *

I want to also call your attention to the need for additional testing facilities. We have now some testing apparatus for which there is no adequate room in the laboratory, and absolutely none in our offices. From this lack of room we are unable to carry out many tests upon the physical structure of pavements and the physical qualities of their constituents, which would be of great value. These could be very well provided for in a new building, and I take it would be of some use in your work.

Very truly yours,

E. A. STEVENS,

Commissioner.

SOIL SURVEY.

The soil survey, carried on in co-operation with the State Agricultural Experiment Station and the Bureau of Soils at Washington, has been prosecuted in Monmouth County. The field work begun May 4, and actively prosecuted until the end of the year, has been in charge of Henry Jennings, formerly of the Bureau of Soils, Washington, D. C., and now on the Survey Staff. He has been assisted by Mr. Dickey of the Bureau of Soils. Each department has paid the salary and expenses of its own employee. Copies of the maps and reports will be prepared for each department.

The area mapped the past season was chiefly in the vicinity of Red Bank and Freehold. The Freehold-Red Bank area is one of great agricultural fertility and importance and at the same time great soil complexity. The smaller area around Lakewood is of less agricultural value and of more uniform soil conditions. Geologically the region is one underlain by various formations of Cretaceous and later age. These are made up of layers of alternating beds of clay, sand, marl (glauconite) and gravel which appear at the surface in comparatively narrow bands. The variations in size, texture, mineral and chemical composition of these beds introduce the first element in the soil differences. Shifting and mixing of materials by the agents of erosion, chiefly rain, running water and wind, addition of varying amounts of organic matter, secondary chemical changes through weathering, have all had their share in producing the present diversities of soil types. In the region mapped a number of series of soils of varying texture, but with a common origin in the same or similar lithologic formations, and having the same general colors, and similar mineral composition, has been recognized. These series are subdivided into soil types which are the units of mapping. In the same type are placed soils having the same texture, structure, content, distribution of organic matter, agricultural value and crop adaptation. The soil map, while in a general way agreeing with the geological map, is on the whole more complex, since the same geological formation may and usually does give rise to several soil

types. On the other hand, two geological formations may be practically identical so far as lithological characteristics are concerned and so give rise to the same series of soils. In the region under study there are three beds of greensand marl of different geologic age and separated vertically by thick beds of sand. Nevertheless they give rise to only one soil series, since their soils have similar mineral and physical characteristics which differentiate them from all other soils of the region. This series is further divided into types, mainly on the basis of texture, a sand, sandy loam, loam and clay loam type being recognized.

In the Freehold-Red Bank region so far as mapped six upland series have been established, having 30 soil types. On the low and poorly drained areas there is one series with four types, besides several miscellaneous types such as coastal beach, tidal marsh, etc., so that 40 types in all have been recognized.

In the southwestern corner of the sheet, covering the region known as the "Pines," one series with six types has so far been recognized.

In addition to the field work considerable work in connection with the soil survey has been done in the office and laboratory. Mr. Gage has made many soil analyses as noted in the paragraph relating to the laboratory. He has also devoted some time to the preparation of manuscript describing the methods of soil analyses used and in tabulating results.

ARCHÆOLOGIC WORK.

The last Legislature included in the Supplemental Appropriation bill an item for archæological work under the direction of the Geological Survey. For the past season this was $500. By direction of the Board, Mr. Lloyd and the State Geologist were appointed a Committee to plan and direct this work. Suggestions regarding the scope of the Survey were solicited from a number of the leading Archæologists of the country and it was finally determined to spend the appropriation for the first summer in locating, as far as possible, the known Indian village and camp sites, burial places, etc. A co-operative arrangement was made

APPENDIX A.

Second Report of the Board of Managers and its Engineer

ON THE

Improvement of Shark River Inlet

AS

Ordered by Act of Legislature, May 1, 1911

Reports of the Committee on the Improvement of Shark River Inlet.

TRENTON, N. J., May 7, 1912.

To the Members of the Board of Managers of the Geological Survey of New Jersey:

GENTLEMEN—The Committee on the Improvement of Shark River Inlet reports that the Legislature included in the Supplemental Bill an appropriation of $1,250 for further surveys and borings necessary to complete the plans for the improvement of the inlet. The Committee authorized Mr. Vermeule to proceed with this work, there being available, in addition to the sum mentioned, about $350.00, the unexpended balance of the former appropriation.

The Committee further reports that the Legislature has appropriated in the regular bill available November 1, 1912, the sum of $35,000 for making a permanent inlet to Shark River "the work to be done by contract and to be under the control, management and supervision of the Board of Managers of the Geological Survey. * * * Provided, however, no part of the said $35,000 shall be paid for any work * * * until the municipalities adjacent to the said Shark River shall have raised and placed at the disposal of the Treasurer of the State of New Jersey the sum of at least $20,000 * * * to be used in conjunction with the moneys appropriated by the State of New Jersey for the purpose of making a permanent mouth or inlet to the said Shark River."

The Committee further reports that steps are now being taken by local parties interested in this improvement to provide for the raising of these funds so that it will be possible to proceed with this work at the beginning of the new fiscal year. The Commit-

tee requests that at this meeting the Board provide for the carrying out of this work.

Respectfully submitted,

HARRISON VAN DUYNE,

Chairman.

TRENTON, N. J., Dec. 3, 1912.

To the Members of the Board of Managers of the Geological Survey of New Jersey:

GENTLEMEN—The Committee of the Board of Managers of the Survey appointed to direct the survey for the improvement of the Shark River Inlet presents the following report:

It has received from C. C. Vermeule, Consulting Engineer—

First. A supplemental report regarding the improvement.

Second. Maps showing the location of the proposed jetties and the proposed changes in riparian lines.

Third. Drawings showing the profile of the jetties and details of construction.

Fourth. Complete specifications for the work.

The new plans differ from those of the preliminary report only in minor details. The general scope of the improvement is unchanged. The alterations are as follows: The curvature of the jetties has been somewhat flattened, so as to make them conform to the natural tendencies of the inlet and to bring about stability in the location of the channel; a stone dike is recommended for the westerly end of the Avon or north jetty instead of the single line of concrete piling, specified in the preliminary report; the easterly end of the north jetty is extended about 300 feet further seaward; the south jetty is extended about 150 feet eastward and placed nearer the north jetty; changes in the riparian lines as established by the State Riparian Commission are recommended. These changes compelled refiguring the cost, the new estimate being $59,268.22 as against $58,000.00.

The Committee has been informed that the Freeholders of Monmouth County have appropriated $10,000, the Borough of Avon $5,000 and the Borough of Belmar $5,000 for this im-

provement, and that a portion of this amount has already been paid into the State Treasury. Under the terms of the law the Board will be in position to advertise for bids as soon as the entire $20,000 is on deposit, but if the total expenditure under the lowest bid be in excess of $55,000, no contract can be entered into.

On November 15th, the Committee made an inspection of the inlet, plans in hand, in company with the Engineer, C. C. Vermeule; Mr. Poole, the Mayor of Belmar; Mr. Leon Taylor, Assemblyman from Monmouth County and the State Geologist. Later they were joined by the Counsel for the County Board of Freeholders. At a meeting of the Committee, held November 15th, at Asbury Park, the following resolutions were adopted:

Resolved, That the Committee approves the supplemental report, plans and specifications submitted by Mr. Vermeule under date of October 21st, 1912, and recommends to the Board their adoption.

Resolved further, That the Committee recommends that authority be given to the State Geologist to advertise for bids for the carrying out of the proposed improvement as soon as he is advised by the State Comptroller that there has been deposited with the State Treasurer the sum of twenty thousand dollars as required by Chapter 130, Laws of 1912.

Resolved further, That the Committee recommends that the Board approve the proposed change in the riparian lines on both sides of the inlet as shown on the maps submitted by its engineer, and urges its adoption by the State Riparian Commission.

Respectfully submitted,

(Signed) HARRISON VAN DUYNE,
CLARENCE G. MEEKS,
T. FRANK APPLEBY,
Committee.

Resolutions Adopted by the Board of Managers.

At the regular meeting of the Board of Managers held December 3, 1912, the following resolutions were adopted:

Resolved, That the supplemental report, plans and specifications submitted by C. C. Vermeule under date of October 21st, 1912, and relating to the improvement of Shark River Inlet, be adopted by the Board of Managers of the Geological Survey, and that the improvement, if made, be made according to them.

Resolved, That as soon as the State Geologist is advised by the State Comptroller that the provisions of Chapter 130, Laws of 1912, relating to the deposit of $20,000 have been complied with, he be authorized to advertise in the

manner prescribed by law for bids for the improvement of Shark River Inlet according to the plans and specifications submitted by C. C. Vermeule under date of October 21st, 1912.

Resolved, That the Board of Managers of the State Geological Survey hereby approves the changes of riparian lines at Shark River Inlet as proposed by its Engineer, C. C. Vermeule, in his report submitted to the State Geologist under date of October 21st, 1912, and requests the State Riparian Commission to refix them accordingly.

Resolved further, That the State Geologist present this resolution to the Riparian Commission and urge favorable action thereon.

Engineer's Report.

NEW YORK, October 21st, 1912.

Dr. H. B. Kümmel, State Geologist:

SIR—In accordance with your instructions, I have proceeded with and completed the surveys at Shark River Inlet and perfected the plans and specifications for the work. I beg to submit herewith the results. Accompanying this report, I send the complete specifications, including the form of proposal and contract. Also the following plans:

1. A plan of Shark River Inlet from the highway bridge eastward to the ocean containing the present bulk-head lines and also the bulk-head lines which I propose in order to make them conform with the jetties and general scheme of improvement.

2. A plan of Shark River Inlet showing the results of the surveys and borings, together with the location of the proposed jetties.

3. A sheet of profiles and cross sections along the line of the proposed jetties.

4. A sheet showing the detailed plans of the reinforced concrete pile jetties.

RESULTS OF SURVEYS.

A careful transit survey was made covering the entire area between the highway bridge and the ocean, together with soundings, the results of which are indicated on the plans by contour

lines showing the depth of water at mean high tides. All surveys and soundings are referred to mean high tide in the ocean as determined from the Survey bench marks. Reference to the plans as compared with the plans submitted in my original report of February 5th, 1912, will show that since that time the Inlet has been forced far to the north and is now immediately to the south of the bulk-head at Garfield Avenue in Avon. The soundings indicate the course of the channel down to the old Inlet and illustrate its tendency to remain near the concave bank in all cases, thus showing that the proposed scheme of curve jetties is in conformity with the natural tendency of the channel. The deepest point in the channel at present is immediately next to the south jetty and a little easterly of the continuation of A Street in Belmar, being eleven feet at mean high tide. As we shall see later, the borings indicate that eleven or twelve feet is apparently about the maximum depth to which the stream is or has been capable of excavating its channel. Off-shore soundings were made as indicated on the map, although it was found impracticable to obtain such soundings between low water-line, which is nearly equivalent to five feet below mean high tide and the line of seven feet depth, owing to the turbulence of the surf and the constant variation in the depth due to the action of the under-tow.

The position of the borings is indicated on the plan, and the results are shown on the sheet of profiles. The following are the records of the borings in detail:

No. I.

0 – 12′	sand.
12′ – 20′	sand and gravel.
20′ – 23′	fine gravel.
25′ – 30′	fine gray sand.
30′ – 35′	marl.

No. II.

0 – 11′	sand.
11′ – 20′	fine gravel.
20′ – 25′	coarse gravel.
25′ – 30′	coarse sand, marl.
30′ – 35′	coarse gravel, marl.

No. III.

0 – 0.5′ water.
0.5 – 10′ sand.
10′ – 15′ sand, gravel.
15′ – 20′ black sand.
20′ – 25′ black sand.
25′ – 30′ black sand, marl.
30′ – 35′ marl.

No. IV.

0 – 1.0′ water.
1.0′ – 10′ sand.
10′ – 20′ sand, a little gravel.
20′ – 25′ marl.
25′ – 30′ marl and silt.
30′ – 35′ marl.

No. V.

0 – 0.5′ water.
0.5′ – 10′ sand.
10′ – 20′ sand and gray clay.
20′ – 31′ clay and silt.
31′ – 35′ fine gray sand.

No. VI.

0 – 15′ sand.
15′ – 22′ sand, some clay.
22′ – 27′ marl.
27′ – 30′ clay, some sand.
30′ – 35′ clay—silt.

No. VII.

0 – 0.5′ water.
0.5′ – 12′ sand.
12′ – 17′ marl, a little sand.
17′ – 20′ sand, little clay.
20′ – 30′ fine black sand.
30′ – 35′ fine black sand.

No. VIII.

0 – 3.75′ water.
3.75′ – 8′ fine sand.
8′ – 12′ marl.
12′ – 20′ fine sand and clay.
20′ – 22′ coarse sand.
22′ – 35′ gravel, little fine sand.

No. IX.

0 – 11′ water.
11′ – 35′ fine gray sand and silt.

No. X.

0 – 12.5′ fine sea sand.
12.5′ – 23′ coarse sand—gray clay.
23′ – 35′ fine sand—traces of clay and silt.

It will be observed that the upper sand or sea sand which has been worked over by the water extends from 8 to 15 feet below

mean high tide. It is usually from 10 to 12 feet. Below this, the samples are mixed with clay and marl to an extent which indicates that they have not been worked over by water during any recent period. In a number of the borings, pure marl was passed through. No obstructions were met within these ten borings.

LOCATION OF JETTIES.

The alignment and location finally adopted for the jetties differ only in unimportant details from the suggestions contained in my original report. The curvature has been flatened somewhat with a purpose of reducing it to just what appears to be sufficient to conform to the natural tendencies of the inlet and to bring about stability in the location of the channel. This brings the south jetty very nearly in line with the present pile and timber jetty built about 1898. This whole jetty is in fairly good condition west of the angle at Station No. 5, being a little west of the extended westerly line of A Street. From that point eastward the old jetty is much weakened, and I propose to substitute for it a concrete pile jetty, Type B, which, however, will not be extended through the beach to the ocean for reasons stated in my original report, and hereinafter referred to. This new jetty will differ somewhat in location from the present pile and timber jetty, and is intended to thoroughly protect the beach to the southeast against a possible cutting through of Shark River in that direction. The further purpose of this jetty is to deflect the stream northward and against the northern jetty which is mainly relied upon to confine the inlet to a fixed position.

That portion of the north jetty indicated as Type C, and which extends from the end of Second Avenue easterly, is recommended to be built as a stone dyke of the cross-section indicated in the plans. This dyke will be on the convex side of the channel and there will consequently be no erosion near the dyke. Its principal purpose is to prevent a breach of the river or the ocean along the north side of the northern jetty and to confine the inlet entirely to the south of that jetty. Easterly, for 750 feet,

the jetty will be of Type B. This will extend from the easterly end of the stone dyke, Type C, about to the present high water-mark on the ocean. This portion of the jetty will be built on a curve with a radius of 716.8 feet. From the easterly end of Type B jetty, there will be 300 feet of Type A jetty, extending southeast into the ocean and terminating at a depth of about 7 feet at mean high tide. This is the most exposed part of the jetty, and will be built of a double line of concrete piles, well tied together at the top and filled between with sand.

RECOMMENDED CHANGES OF BULK-HEAD LINES.

On a sheet especially devoted to that purpose, I have shown by means of tints the present and the proposed bulk-head lines. My reason for suggesting certain modifications of these lines is to make them conform to the general scheme and purpose of the improvement, and also to coincide with the proposed jetties. The proposed change in the Avon bulk-head lines begins in the present bulk-head line at a point 260 feet westerly from the easterly line of Second Avenue and 288.25 feet southerly from the southerly line of Washington Avenue. Thence the proposed line extends to a point in the proposed north jetty, said point being 160 feet easterly from the produced easterly line of Second Avenue and 411 feet southerly from the southerly line of Washington Avenue. Thence a line extends easterly on a curve to the left with a radius of 819 feet, said curve being tangent with the proposed bulk-head line previously described, a distance of 630 feet, measured in chords of 100 feet; and thence by a curve to the right with a radius of 716.8 feet, a distance of 830 feet, measured in 100-foot chords, to a point in the ocean; thence southeasterly and tangent to the aforesaid curve into the Atlantic Ocean.

The Belmar bulk-head line has been changed throughout in order that the contraction of the river as we proceed easterly to the inlet may be continuous and gradual, as this is the only method by which we can prevent injurious and troublesome deposits which are sure to occur at points of sudden enlarge-

ment of the channel. There is, on this side of the river, an extensive flat only slightly submerged at high tide. Preparations are now being made to dredge the river at this point and use the dredged material to fill in this flat. If this improvement is conducted properly and along the lines which will be defined by the bulk-head lines which I now propose, it will be beneficial and will conform in all respects to the purposes of the proposed jetties. The location of the proposed bulk-head line is described as follows:

Beginning at the southerly abutment of the highway bridge at a point in the present bulk-head line, thence running northeasterly to a point 330 feet northerly from the north line of Fifth Avenue and 200 feet westerly from the produced westerly line of E Street; thence northeasterly to a point 900 feet northerly from the north line of Fifth Avenue and in the produced easterly line of E Street; thence northeasterly to a point in the produced easterly line of D Street, 1,300 feet distant from the northerly line of Fifth Avenue; thence easterly to a point 200 feet easterly from the produced easterly line of C Street and 845 feet northerly from the northerly line of Third Avenue; thence easterly to a point in or near the present jetty, said point being 140 feet distant from the southerly line of First Avenue, measured on a perpendicular thereto at the intersection of said southerly line of First Avenue with the easterly line of the River Road; thence easterly along the present jetty to a point 30 feet westerly from the produced westerly line of A Street and 220 feet northerly from the southerly line of First Avenue; thence northeasterly to a point 108 feet easterly from the produced westerly line of A Street and 292 feet northerly from the southerly line of First Avenue; thence by a curve of 1,298 feet radius curving to the left 240 feet, measured by chords of 100 feet; thence curving to the right with a radius of 478.3 feet, a distance of 552 feet, measured by chords of 100 feet; thence tangent to the aforesaid curve southeasterly into the Atlantic Ocean to an intersection with the present bulk-head line.

Should the above proposed changes of the bulk-head lines be approved, I would suggest that a recommendation to this effect be made to the Riparian Commission, but I presume that such recommendation would have to be supported by an application from the owners of the riparian rights thereby effected.

TYPE OF CONSTRUCTION.

I have already alluded to the substitution of a stone dyke for the single line of reinforced concrete piles and caps suggested in my original report for Type C jetties. The general form of construction of Type A and Type B jetties remains similar to what was then suggested, although the details have been more carefully worked out and some additional strength has been given to Type A. Generally, Type B consists of a continuous line of reinforced concrete piling tied together at the top with a reinforced concrete cap or beam and braced at intervals of 10 feet on the side away from the channel by a reinforced concrete pile and brace beam. The side next to the channel I propose to protect with stone riprap, as indicated in the plans, in order to prevent too deep a cutting by the current immediately along the face of the piling, as such cutting will diminish the support and security of the jetty.

Type A jetty will consist of two lines of continuous reinforced concrete piling tied together with reinforced concrete caps and braced by cross beams of reinforced concrete at intervals of 10 feet, the space between to be filled with sand. The two bents on the ocean end I propose to cap over with a plate of reinforced concrete 12 inches thick, in order to bind the whole together with a cellular form to resist more effectually the pounding of the waves.

ESTIMATE OF COST.

The quantities are somewhat modified from those given in my original report owing to an increase in the amount of Type A jetty and some other changes more particularly the change to a

stone dyke for Type C. The latter change effects some economy which is offset, however, by the increase in amount of Type A and Type B reinforced concrete jetty. I propose to pay for the Portland cement used by the barrel, in order to be able at any time to change the proportions of cement used in the concrete, in order to obtain the best results and to fill the voids in the stone and sand, as such voids may be determined by actual experiment. I have changed the form of my estimate throughout in order to make it conform to the form of proposal which I have found best for the purpose. I have also entirely recomputed the cost in detail for the purposes of this estimate. In each case I have added the fifteen per cent. for the contractor's profit to the particular item dealt with, consequently this does not appear at the end as formerly. The result is as follows:

Portland Cement, 3,706 bbls. @ $1.55,	$5,444 30
Steel Reinforcing bars, 410,234 lbs. @ 2.3c.,	9,435 38
Standard Jetty piles 26 ft. long— 300 @ $19.95,	5,985 00
" " " 24 " " 710 @ $17.10,	11,641 00
Brace and Partition piles 28 ft. long— 12 @ $19.95,	239 40
" " " " 20 " " 56 @ $14.30,	800 80
" " " " 16 " " 103 @ $11.40,	1,174 20
Reinforced Concrete in Caps, Beams and Plates, 11,890 cu. ft. @ 25c.,	2,972 50
Stone in Jetty, 1,865 cu. yds. @ $3,	5,595 00
Stone Rip Rap, 1,660 cu. yds. @ $2.50,	4,250 00
Dredging, 10,000 cu. yds. @ 25c.,	2,500 00
Removing old piles, 100 @ $5,	500 00
Removing old timber,	1,000 00
	$51,537 58
Contingencies, omitted items, engineering, etc., 15%,	7,730 64
	$59,268 22

THEORY OF THE IMPROVEMENT.

The broad considerations which influenced my original recommendations as to the alignment and location of the jetties have received further attention from me, but I have found no reason to change the conclusions which I then reached. Later studies of the movement of the sand and of the inlet appear to entirely confirm what had been observed and set out in my original report. The strong tendency of the inlet to shift to the north has been again exhibited in the recent changes. This tendency I

ascribe to the steady pressure of the sand moving along the beach to the northward under the combined influence of the waves, and the southeasterly winds which prevail during so large a part of the year, and which are the most active in determining the transporting tendencies of the waves along the beach. This movement is gradual, but is so continuous that it cannot be prevented by any ordinary construction. The effect of the northerly storms, however, although not continuous, is sudden and violent, and the transporting action of the waves during these storms is in the contrary direction, namely, southerly. The suggestion has been made that the northerly movement of the sand should be guarded against by the extension of a dyke at the southerly side of the inlet. I am of the opinion that such a measure will be ineffective and that such a dyke would rapidly fill with sand at the southerly side so that the beach would again extend out beyond the end of it, and the northerly movement would again continue. So long as the inlet is open, this sand moving northerly must be swept in with the flood tide, and no arrangement of jetties can prevent such action. Because of this consideration, I have concluded that this northerly movement of the sand must be provided for and taken care of by allowing it to be carried into the inlet on the flood tide and providing so far as possible that it shall be again carried out on the ebb tide until it passes the end of the northerly jetty, after which it will continue its travels northerly up the beach. What I hope to accomplish by the proposed jetties is to prevent the inlet moving northward and to keep it in a fixed position by means of the northerly jetty. So long as it is kept in this position, I believe it will be amply able to take care of the sand slowly moving northward, for the reason that this sand is moved northward under a current less powerful than the current through the inlet, and, indeed, a large part of it is moved northward by the wind alone, and is consequently fine material, which will be easily transported by the water of the inlet.

In addition to its usefulness in confining the inlet to a fixed position, the northerly jetty, it is hoped, will also prove effective in preventing the sudden transportation of large quantities of sand into the inlet during northeasterly storms.

So long as the inlet is held in a fixed position, as it will be by the proposed jetty, even should it temporarily fill up, it must break out again and must break out along the south side of the jetty in the same position as before, whereas at present it is free to move to a new position further north. When it does so move to the north, it usually, in time, becomes so feeble in its action that it closes up entirely and then breaks out anew in some other place, which at the time happens to be the point of least resistance. The inlet cannot remain permanently closed for any length of time, owing to the accumulation of fresh water which will eventually overflow the beach and cut a new opening. I believe that the proposed jetty construction will make the entire closing up of the inlet extremely improbable.

OMISSION OF SOUTH JETTY THROUGH BEACH.

As already stated, it is practically impossible to hold the northward moving sand on the beach by means of a jetty at the south side of the inlet. Another reason for omitting this jetty was stated in my original report to be that if built, it is a practical impossibility to accurately fix its distance from the north jetty at the present time. If it is built too far from the north jetty, so that the channel between is larger than is required to accommodate the inflowing and outflowing tides, then the sand will continue to accumulate on the channel side of the south jetty and the jetty will be useless. If, on the other hand, the distance between the jetties is too small, the tidal action will be limited and the tidal prism in the bay will be diminished in volume thereby partially defeating the purpose of this improvement. There has not been heretofore and is not likely to be any tendency of the inlet to cut away the beach at its southerly side. The south jetty as planned will be sufficient to deflect the inlet northerly and the action of the wind, together with the steady northward pressure of the sand, will unquestionably hold the inlet in a fixed position. After the construction of the north jetty, in course of time, the regimen of the inlet will become established, and its needs as to width may then be determined with certainty. When this occurs, it will be

possible to accurately determine the proper position for a bulk-head at the south side of the inlet if the interests of the property owners will be served by such a bulk-head, but meanwhile, its omission will effect a large saving in cost without in any respect impairing the efficiency of the works.

SOUTHEASTERLY TREND OF THE INLET.

I called attention in my original report to the consistent tendency of all inlets to take a southeasterly course through the beach to the ocean. There unquestionably exists a strong tendency to this location for the principal channel, for the reasons which I set forth in my previous report, being principally the action of the wind. I have been asked whether this southeasterly direction might not increase the accumulation of sand moving northerly up the beach, or, in other words, whether the northerly jetty might not act as a sand catch. It has been suggested that the direction might on this account more properly be to the east or northeast. I have given full consideration to this phase of the problem. It should be apparent at a glance that whatever the direction of the mouth of the inlet, the sand moving northerly must, as it reaches the inlet, be swept in with every flood tide. A cursory glance at the map might suggest that it would be possible to deflect the sand across the mouth of the inlet by having the jetties project northeasterly, but proper consideration of the subject will show that it is manifestly impossible that the sand should travel across the mouth of the inlet and resume its northerly course up the beach at times when there is a strong current in shore on the flood tide. I am satisfied from my observation and examination of the question that there is no method by which we can prevent the sand being carried in on the flood tide, and we must trust to proper regulation of the channel in such manner that the sand carried in will be carried out again on the ebb tide, and when so carried out beyond the end of the north jetty, it will, of course, resume its travel northerly along the beach. A study of the sketches submitted in my previous report must convince us that the old jetties, which faced nearly eastward, did

not line up with the natural tendency of the inlet; and furthermore that their facing eastward did not prevent the sand from filling up the inlet. If they had faced northeasterly, conditions would have been still worse. During the northeasterly and easterly storms, which are the most severe and protracted, the sand is transported shoreward in large quantities, and also the ebb tide is usually very feeble in action, owing to the position of the wind. At such times jetties facing easterly or northeasterly invite large accumulations of sand in the inlet. I believe that the jetty which I have planned, running in a southeasterly direction, will in large measure exclude this sand, and that such part of it as finds its way around the end of the jetty, however feeble the ebb tide, will at such times continue its travels down the beach and will not be carried into the inlet.

I have thought it best that I should set forth these considerations, and the theory upon which I have located the jetties, somewhat more in detail, although I had intended that it should be made clear in my previous report. It should be borne in mind that this report should be considered with the previous report, as I have not intended to repeat what was therein set forth, but have endeavored to supplement and amplify it.

Respectfully submitted,

CORNELIUS C. VERMEULE.

APPENDIX B.

List of Bench Marks in Bergen, Essex, Hudson, Morris, Passaic, Sussex, Union and Warren Counties.

Primary Bench Marks.

Dr. H. B. Kümmel, State Geologist, Trenton, N. J.:

DEAR SIR—In compliance with your instructions, I have had a careful examination made of the primary bench marks established by the Geological Survey originally during the progress of the topographic survey in 1885, 1886 and 1887. A full list of these bench marks was first published in Volume I of the final report in 1888, and republished in Volume IV, Physical Geography of 1895. The primary purpose of the work was to control and form a basis for the topographical levels. The bench marks were established upon the most permanent structures then available, such as bridges and public buildings. It has been found that the progress of rebuilding and removal of such structures has caused the loss of a large number of the original bench marks, and the present work of revision was planned with a view to checking the remaining original bench marks and substituting other permanent ones on newer structures, to take the place of those which have been lost. During the progress of this work a large number of additional bench marks were established. The following list includes both the original bench marks and those recently established. All elevations have been rechecked and in case those now given differ from the original elevations the present elevations are to be taken as correct. Some clerical and topographical errors were discovered in the original list and these have been rectified. The field work of the original leveling operations has been found to be generally correct and the errors which have been rectified are entirely clerical or topographical. As in the original list, the accompanying list is arranged by counties and by localities, the arrangement of the latter being alphabetical for each county. The work of the past season has been confined to the Counties of Sussex, Warren, Morris, Passaic, Hudson, Essex and Union.

Respectfully submitted,

C. C. VERMEULE.

BERGEN COUNTY.

ALLENDALE. Eleva., 321.81 ft.
A cross cut in the west end (about 6 inches from north end of west truss, 6.3 feet from the end and near the edge) of the north abutment of the bridge which carries the Erie Railroad over Hohokus Creek, three-quarters of a mile south of the depot.

ALLENDALE. Eleva., 269.49 ft.
A cross cut in the southeast corner of the second step from the top of the east end of the north abutment of the bridge which carries the Erie Railroad over a small brook, about 300 yards south of the station.

BLAUVELTVILL, N. Y. Eleva., 182.80 ft.
A cross cut in the outside corner of the west end of the south abutment of the bridge which carries a road over the Piermont Branch of the Erie Railroad, at the station.

CARLSTADT. Eleva., 145.85 ft.
A cross cut in the north end of the doorsill (near the edge and close up to the door jamb) of the entrance to the public school building, which stands on the east side of Third Street, between Hoboken and Broad Streets. This entrance is near the north end of the school building, and leads into the old part.

CLOSTER. Eleva., 65.06 ft.
A cross cut in the east corner of the sill of the front door of C. Hansen's feed store, on the west side of the Erie Railroad, at the junction of two roads.

CLOSTER. Eleva., 65.06 ft.
A cross cut in the north end of the doorsill (3½ inches from the edge and 3½ inches from the wall) of the most northerly entrance to the public school building, on the east side or front. The school building is located between High and Demarest Streets, and faces the east.

CLOSTER. Eleva., 30.65 ft.
A cross cut in the west end (3.3 feet from I-beam, 2.5 feet from end, 1.6 feet from edge, 0.83 foot from back wall end, 3.2 feet below track) of the north abutment of the bridge which carries the northern branch of the Erie Railroad over Dwar's Kill, three-quarters of a mile north of the station. The cross is cut on the shelf of the abutments supporting the north ends of the I-beam.

CLOSTER. Eleva., 25.71 ft.
A cross cut in the south end (4.7 feet from I-beam, 0.6 foot from end, 1.95 feet from edge, 0.45 foot from retaining wall behind, and 3.05 feet below track) of the east abutment of the bridge which carries the northern branch of the Erie Railroad over the North Branch of Dwar's Kill, 1 mile north of the depot. The cross is cut on a shelf of the abutment supporting the south end of the I-beam.

DEMAREST. Eleva., 38.87 ft.
A cross cut in the south end of the sill of the front door of the station of the Northern Railroad of New Jersey.

DUNDEE LAKE. Eleva., 41.14 ft.
This bench mark is on the New York, Susquehanna and Western Railroad bridge crossing the lake. The point is a cross cut in the northwest corner of the iron bed-plate on which rests the most easterly truss, on the north side of the track.

EAST RUTHERFORD. Eleva., 82.29 ft.
This bench mark is a point taken on the northwest corner of the base of a monument, "Dedicated to the Memory of Soldiers and Sailors Who

Fought in Defence of the American Flag," standing in the junction between Paterson Avenue and Grove Street, opposite Second Street. This monument is a cannon mounted upon a granite base. The point is on the corner of the granite base, between the breech and the trunnion bed. Looking towards the muzzle, it is on the left of the cannon.

EMERSON. Eleva., 47.97 ft.
A cross cut in the north end of doorsill (.35 foot from outer edge, 1.2 feet from north end, and near the corner of a bay-window) at the entrance to a building owned by R. Alexander, standing on the west side of the main road, opposite the point where this road crosses the New Jersey and New York Railroad. This building has a yellow brick front, with stone trimmings, red brick sides, and is two stories high; the upper story is occupied as apartments, the lower story is used as a store, and occupied by the Emerson Grocery Company.

ENGLEWOOD. Eleva., 36.48 ft.
A cross cut in the southeast corner of a flat stone on the east end of a stone culvert which carries the Northern Railroad of New Jersey over a small stream 200 feet south from Slocum Avenue and one-quarter of a mile north of the station.

ENGLEWOOD. Eleva., 27.49 ft.
A cross cut in the east end of the doorsill (8 inches from the edge, and near the door jamb) of the only entrance in the north end of the station, which stands on the east side of the Northern Railroad of New Jersey between Demarest and Palisade Avenues.

ENGLEWOOD. Eleva., 8.82 ft.
.A cross cut in the summit of a stone at the north end of a culvert, just west of the Northern Railroad of New Jersey, which carries Forest Avenue over a small run.

GARFIELD. Eleva., 12.96 ft.
A cross cut in the east end of the coping stone of the north wing wall of the east abutment of the bridge which carries Passaic Avenue over Passaic River. This point is outside of hand rail, 0.32 foot from edge, 3.3 feet from east end of wing wall, and 12.85 feet from north end of east abutment.

GARFIELD. Eleva., 34.26 ft.
A cross cut in the northwest corner of the highest step of the west end of the south abutment of the bridge which carries the short cut of the Erie Railroad over Passaic Avenue. The south end of the bridge truss rests upon this step.

HACKENSACK. Eleva., 12.50 ft.
A cross cut in the west end of the sill of the main front door of the First Reformed Church, on Court Street.

HACKENSACK. Eleva., 19.86 ft.
A cross cut in the southeast corner of the east end of the doorsill (2.15 feet from outer edge, 0.36 foot from east side of doorway and 0.13 foot from bronze door saddle) of the most easterly of the three front entrances to the Bergen County Courthouse, which stands on the southeast corner of Main and Court Streets. The courthouse faces Court Street.

HACKENSACK. Eleva., 22.70 ft.
A cross cut in the west end of the doorsill of the entrance to apartments over the store, in a brick building on the north side of Anderson Street, west of Anderson Street depot. This building was erected in 1894 by G. A. Mattjetschenk.

HASBROUCK HEIGHTS. Eleva., 151.27 ft.
A cross cut in the west end of sill of first window east of the front, or Franklin Avenue, entrance of the public school building, which stands on top

of the ridge, on the south side of Franklin Avenue between the Boulevard and Burton Avenue. The window is below the water table and opens into the basement of the building.

HIGHWOOD. Eleva., 48.95 ft.
A cross cut in the northeast corner of the coping of the retaining wall at the east end of the south abutment of the Northern Railroad of New Jersey bridge over a brook, about 500 yards south of the station.

HILLSDALE. Eleva., 52.76 ft.
A cross cut in a brownstone block on the top of the first step (6 inches from the east end and 6 inches from edge) on the east end of the north abutment of the bridge which carries the New Jersey and New York Branch of the Erie Railroad over Pascack Brook, about 1,600 feet south of the station. The north end of the truss of the bridge rests on the first step.

HOHOKUS. Eleva., 194.69 ft.
A cross cut in the southwest corner of the coping of the west parapet of the culvert which carries the Erie Railroad over Hohokus Creek.

KINGSLAND. Eleva., 63.12 ft.
A cross cut in the south end of the coping of the east wing wall of the north abutment of the bridge, which carries Ridge Road over the Delaware, Lackawanna and Western Railroad, about 800 feet west of the station. This cross is about 1 foot from the south end of the wing wall, between the hand rail and the inner edge of the coping.

KINGSLAND. Eleva., 54.93 ft.
A cross in the end of a piece of a railroad rail, standing erect in a concrete foundation, on the north slope of a cut, 40 feet north from the westbound track, 15 feet from top of slope and 25 feet from the east end of the east wing wall of the north abutment of a bridge which carries the Ridge Road over the Delaware, Lackawanna and Western Railroad, about 800 feet west of station. This is probably a railroad bench mark.

LODI. Eleva., 22.37 ft.
A cross cut in the southeast corner of the south end of the west abutment of the bridge which carries Passaic Avenue over Saddle River.

LODI. Eleva., 34.47 ft.
A cross on the south end of the sill of the second window from the south, under the water table, in the wing of Public School Building No. 1, which stands on the southeast corner of South Main and Hunter Streets and faces South Main Street. There is an entrance on each side of the wing in front, on the South Main Street side, and four windows under the water table opening into the basement. The bench mark is on the sill of the second window from the south.

LODI. Eleva., 45.42 ft.
A cross cut in the northwest corner of the west end of the coping of the north wall of the culvert which carries Union Avenue over a small stream, about 2,100 feet east of South Main Street.

LODI TOWNSHIP. Eleva., 30.68 ft.
A cross cut in the coping of the east wall (directly over the middle of the arch) of the bridge which carries Terrace Avenue over a gulley just south of the right of way of the old Lodi Railroad, now abandoned. This arch bridge is just south of the south boundary of Hackensack.

LYNDHURST. Eleva., 66.56 ft.
A cross cut in the extreme south end (against the face of the brick wall) of the sill of the most southerly door of the two entrances to the Lincoln School, on the west and facing the Ridge Road, between the Delaware, Lackawanna and Western Railroad and Valley Brook Avenue. There are two doors for an entrance with a window between them. The Lincoln School is one of the school buildings belonging to Union Township.

MAHWAH. Eleva., 309.06 ft.
A cross cut in the northeast corner of the east end of the south abutment of the bridge which carries the Erie Railroad over a road leading from Masonicus to Wanamaker's Mills, about three-eighths of a mile south of the station. The cross is on the top of a series of steps, which form a shelf, upon which rests the north end of the I-beam.

MAHWAH. Eleva., 297.76 ft.
A cross cut in the northeast corner of the north end of the retaining wall on the east side of the Erie Railroad. The cross is about 325 feet north of the station.

MAHWAH. Eleva., 274.54 ft.
A cross cut in the east end (near the edge, 1.35 feet from the bedplate and 10.2 feet from the end) of the north abutment of the bridge which carries the Erie Railroad over the Mahwah Creek. The cross is on the stone upon which rests the bedplate of the north end of the most easterly truss. This bridge is 1,400 yards north of the railroad station.

MONTVALE. Eleva., 140.34 ft.
A cross cut in the southwest corner of the south end of the east abutment of the bridge which carries East Avenue over Pascack River, 900 feet west of the railroad station.

MONTVALE. Eleva., 179.25 ft.
A cross cut in the southeast corner of the coping stone, 1.7 feet above the ground, in the west end of the south wall of a small highway culvert, 400 feet north of the station and just west of the Erie Railroad.

NANUET, N. Y. Eleva., 298.16 ft.
A cross cut in the windowsill (3.6 inches from the west end and 4.2 inches from the edge) west of the entrance to the store owned by William Hutton, Jr., on the north side of the road leading from Spring Valley to Nyack, and just east of the crossing of the Piermont and New City branches of the Erie Railroad. The front of the store is divided into three equal parts, the center part has an entrance to the store, with a large window each side. The sills of the windows and door are at the same level.

NANUET, N. Y. Eleva., 293.60 ft.
A cross cut in the northeast corner of the stone cap of the pier upon which rests the northeast of five columns which support the roof of the shed shelter, attached to the east end of the Erie Railroad station.

NEW MILFORD. Eleva., 12.62 ft.
A cross cut in the south end of the doorsill (5.3 inches from south side of doorway and 11 inches from door) of the most southerly entrance, on the west side of the Hackensack Water Company's pumping station. This door is the entrance to the old engine house, now known as Engine House No. 1. Over the arched entrance is the date "1882."

NORDHOFF. Eleva., 9.87 ft.
This bench mark is on the north end of the sill of the most northerly window in the front, or east side, of the lodge at the entrance to the late W. W. Phelps' Teaneck estate.

NORDHOFF. Eleva., 4.25 ft.
A cross cut in the northwest corner of the west end of the south abutment of a bridge which carries the Northern Railroad over a small stream 600 feet north of the station.

NORTH ARLINGTON. Eleva., 128.24 ft.
A cross cut in the center of a brownstone monument standing on the north side of Kearny Avenue on the line between the cemetery and the public school lot.

NORTH ARLINGTON. Eleva. 141.00 ft.
A cross cut in the south end of the bluestone doorsill of the front entrance to the Town Hall, on the east side, one hundred feet back of Kearny Avenue. This building was formerly used as a school house. A new school house has been erected just north, and this building is now used for a town hall.

NORTH HACKENSACK. Eleva., 9.54 ft.
A cross cut in the middle of a series of five steps, on the west end of the north abutment of a bridge which carries the New Jersey and New York Railroad over a small stream, 700 feet south of the station. The stream at this point is the dividing line between the town of Hackensack and Riverside Borough.

NORTHVALE. Eleva., 37.89 ft.
A cross cut in the south end of the north doorsill of the entrance to the waiting room on the west side or back of the station. The station is of brick with stone sills. There are two doors on the west side near the south end and one near the north end, leading into the waiting room. The cross is cut on the sill of this door.

NORTHVALE. Eleva., 33.47 ft.
A cross cut in the northeast corner of the north end of the west wing wall of the north abutment of the bridge which carries the road leading from Northvale to Tappan over Tappan Brook. This bridge is about 375 feet south of the State line.

NORWOOD. Eleva., 32.77 ft.
A cross cut in the east wall, over the center of the arch, of a culvert which carries the Northern Railroad of New Jersey over a small run, 800 feet north of the station.

ORADEL. Eleva., 16.03 ft.
A cross cut in the south end of the west abutment (4.1 feet below the east end of the south wing wall, and 5.6 feet above the ground) of the bridge which carries Oradell Avenue over Hackensack River. This cross is cut on the shelf of the abutment supporting the west end of the truss. The bridge is about 250 feet east of the depot.

ORANGEBURG, N. Y. Eleva., 113.82 ft.
A cross cut in the east corner of the coping, on top of and at the extreme south end of the long abutment, of the bridge which carries the Piermont Branch of the Erie Railroad over the West Shore Railroad.

PALISADE MONUMENT. Eleva., 460.21 ft.
This bench mark is on the summit of the State-line monument on the top of the Palisades.

PALISADE MONUMENT. Eleva., 453.08 ft.
This bench mark is a cross cut on a rounded knob of the bedrock, 7.8 feet southwest of the monument.

PARK RIDGE. Eleva., 142.26 ft.
A cross cut in the east end of the sill of the most westerly of the three doorways of the front entrance to the public school building, which stands on the southeast corner of Main Street and Park Avenue.

PASSAIC JUNCTION. Eleva., 53.20 ft.
A cross cut in the southeast corner of the lowest step at the east end of the north abutment of the bridge which carries the Bergen County Short Cut of the Erie Railroad over the New York, Susquehanna and Western Railroad.

PEARL RIVER, N. Y. Eleva., 212.81 ft.
This bench mark is on the cross cut on the State-line monument, 2.8 feet west of the west rail of the New Jersey and New York Branch of the Erie Railroad, about one-half mile south of the station.

PEARL RIVER, N. Y. Eleva., 216.39 ft.
A cross cut in the north end of the east abutment of the bridge which carries Central Avenue over a small stream, about 500 feet west of the railroad.

PEARL RIVER, N. Y. Eleva., 219.83 ft.
A cross cut in the west end of the north concrete wall of a bridge which carries Washington Avenue, or the direct road from Pearl River to Upper Montvale, over a small stream, about 500 feet west of the railroad.

PEARL RIVER, N. Y. Eleva., 224.95 ft.
A cross cut in the top of a boulder, cemented in the west end of the north abutment at the end of the hand rail of the bridge which carries the road leading from Pearl River to Upper Montvale over Pascack Brook, five-eighths of a mile west of Pearl River.

PEARL RIVER, N. Y. Eleva., 225.50 ft.
This bench mark was taken on the cross cut in the new eighth milestone on the State line. This stone is about half way between Pearl River and Upper Montvale. There is an old mile stone here also. The elevation of the top of the old stone is 226.18 feet.

RAMSEY. Eleva., 344.00 ft.
A cross cut in the water table, in front, at the offset, 23.5 feet from the northwest corner of the Dater Building, on the south side of Main Street, giving, on the west, the right of way of the Erie Railroad, and opposite the station.

RAMSEY. Eleva., 339.68 ft.
A cross cut in the northwest corner of the shelf, upon which rests the south end of the truss (7 feet from the most westerly rail of the southbound tracks, 6.9 feet from the end of the wing wall and 4 feet above the brook) of the south abutment of the bridge which carries the Erie Railroad over a brook, $1^3/_{16}$ miles north of the depot and 60 feet south of a highway crossing.

RIDGEFIELD. Eleva., 14.35 ft.
A cross cut in the south end of the sill of the front door of the ladies' waiting room of the station of the Northern Branch of the Erie Railroad.

RIDGEFIELD. Eleva., 5.96 ft.
A cross cut in the southwest corner of the west end (at the northwest corner of the draw) of the north abutment of the bridge which carries Bergen Turnpike over Overpeck Creek, half a mile west of the depot.

RIDGEFIELD PARK. Eleva., 6.77 ft.
This bench mark is a cross cut in the northwest corner of the north end of the west wall of a culvert which carries the West Shore Railroad over a small stream, one-third of a mile north of the depot. (Partially destroyed.)

RIDGEFIELD PARK. Eleva., 6.85 ft.
A rounded knob, with the letters "B. M." closely cut, in the southwest corner of the south end of the west wall of the bridge which carries the West Shore Railroad over a small stream, one-third of a mile north of the depot. This bench mark and the one above are on the same wall of the culvert.

RIDGEWOOD. Eleva., 134.55 ft.
A cross cut in the south end of the doorsill, under a bronze tablet, of the corner and main entrance to the Ridgewood Trust Company's building, which is on the southeast corner of Ridgewood Avenue and Prospect Street.

RIDGEWOOD. Eleva., 153.97 ft.
A cross cut in the east end (2 feet from truss, 12.4 feet from end and close to the edge) of the north abutment of the bridge which carries the Erie Railroad over a road, three-quarters of a mile north of the depot. The cross is on a shelf of the north abutment, upon which rests the north ends of the truss.

RIVER EDGE. Eleva., 7.74 ft.
A cross cut in the northwest corner of a shelf upon which rests the east end of the draw, on the north end of the east abutment of the drawbridge which carries a road over the Hackensack River, 300 feet east of the depot. This shelf is 2.6 feet below the top of the west end of the north wing wall of the east abutment and 2.2 feet above a retaining wall along the river.

RUTHERFORD. Eleva., 47.53 ft.
A cross on top of a stone monument located in a small circular flower bed around a flag pole at the junction of streets near the depot.

RUTHERFORD. Eleva., 43.14 ft.
A cross cut in the extreme east end of the doorsill of a double door entrance to the railroad station from the street on the south side. Over this door is the name "Erie Railroad."

RUTHERFORD. Eleva., 76.94 ft.
A cross cut in the south end of the doorsill (under the arch) of the entrance to the Municipal Building, on the west side of Park Avenue, between Franklin Place and Ridge Road.

SUFFERN, N. Y. Eleva., 287.49 ft.
This bench mark is the top of the new fifteen-mile stone of the State line which stands on the east side of Ramapo Avenue, west of the Erie Railroad.

TAPPAN, N. Y. Eleva., 60.03 ft.
This bench mark is the top of a State-line monument on the east side of the road leading from Tappan to Harrington Park. near the German Church.

TAPPAN, N. Y. Eleva., 108.47 ft.
This bench mark is the top, on the cross, of the new three-mile monument of the State line.

TAPPAN, N. Y. Eleva., 109.158 ft.
This bench mark is the top or highest point of the old third monument of the State line.

TENAFLY. Eleva., 48.06 ft.
A cross cut in the south end of the sill of the north front door of the station of the Northern Branch of the Erie Railroad.

WALLINGTON. Eleva., 9.65 ft.
A cross cut in the northwest corner of the north end of the shelf, upon which rests the east ends of the truss, of the east abutment of the drawbridge which carries the road from Wallington to Passaic over the Passaic River.

WOODRIDGE. Eleva., 136.69 ft.
This bench mark is taken on the hole in the top of a brownstone monument, standing on the west side of Hackensack Avenue, on a line with the north side of Moonachie Avenue (projected.) This monument is evidently a property monument.

WOODRIDGE. Eleva., 188.12 ft.
A cross cut in the north end of the sill, of the first window south of the Hackensack Street entrance, of the public school building on the southwest corner of Hackensack and Union Streets.

WALDWICK. Eleva., 228.41 ft.
A cross cut in the northeast corner of the stone cap, on the concrete base, west of the tracks, upon which rests the most northerly of the pillars supporting the west end of the bridge which carries a highway over the Erie Railroad one-quarter of a mile south of the depot.

WESTWOOD. Eleva., 54.56 ft.
A cross cut in the southwest corner of the north wing wall on the west side of the arch bridge which carries the New Jersey and New York Rail-

road over a brook south of the station. The cross is cut near the end of the first step of north wing wall, 2 inches from the end and 3½ inches from the edge.

WESTWOOD. Eleva., 74.69 ft.
A cross cut in the northeast corner of the east end of the stone doorsill of the Westwood Avenue entrance to the First National Bank building standing on corner of Westwood and Center Avenues.

WOODCLIFF LAKE. Eleva., 96.98 ft.
A cross cut in the west end of the south wall of the concrete culvert which carries the road over Hackensack Water Company's storage reservoir.

ESSEX COUNTY.

BELLEVILLE, Eleva., 32.97 ft.
A cross cut, east of the iron fence, nearly in the center of the first coping stone, at the south end of the west parapet of the bridge which carries Washington Avenue over Second River.

BELLEVILLE. Eleva., 111.63 ft.
A cross cut in the east corner of the sill of the first window west of the front entrance to Montgomery School No. 2, which stands on the north side of Montgomery Avenue, about 500 feet east of the bridge which carries said avenue over the Morris Canal.

BLOOMFIELD. Eleva., 141.32 ft.
A cross cut in the west end of the stone sill of the middle of the three front doors of the old Presbyterian Church.

BLOOMFIELD. Eleva., 132.75 ft.
A cross cut in the extreme northwest corner of a large flat stone in th north end of the east abutment, upon which rests the east end of the nort truss of the iron bridge which carries the Greenwood Lake Branch of th Erie Railroad over the Morris Canal.

BLOOMFIELD. Eleva., 181.19 ft.
A cross cut in the northwest corner of the west abutment, about 6 fe 4 inches above the towpath, of the bridge carrying the first road north c plane No. 11 over Morris Canal.

BLOOMFIELD. Eleva., 183.88 ft.
This bench mark is on the northeast corner of the west abutment of bridge which carries a road over the Morris Canal about 2⅜ miles nor of the old Presbyterian Church. On this corner are two letters cut on t stone: "J. W." The point is on the "W." The west end of the north tru of the bridge rests upon this stone.

BLOOMFIELD. Eleva., 177.52 ft.
A cross cut in the lowest step of the north wing wall of the west abutme of the bridge which carries a road over the Morris Canal at Brookdale.

BLOOMFIELD. Eleva., 168.49 ft
A cross cut in the most westerly coping stone (5 inches from the ir post of the hand rail) of the south wing wall of the west abutment of t bridge which carries a road over Yantecaw, or Third River, at Brookdale

BLOOMFIELD. Eleva., 182.19 ft
A cross cut in the water table, between the two pilasters, to the right of t entrance to the public school building at Brookdale.

BLOOMFIELD. Eleva., 128.97 ft
A cross cut in the south end of the doorsill of the Broad-street entra to the Bloomfield National Bank Building, which stands on the northw corner of Bloomfield Avenue and Broad Street.

BLOOMFIELD. Eleva., 150.46 ft.
This bench mark is the top of a round knob cut in the southeast corner of a brownstone monument standing in front of Christ Episcopal Church, at the junction of Bloomfield Avenue and Liberty Street.

EAST ORANGE. Eleva., 181.86 ft.
A cross cut in the extreme north end of the third stone step from the top (and fourth from the bottom) behind a pilaster on the left of the entrance of the East Orange Free Public Library, which stands on the southeast corner of Main Street and Munn Avenue.

EAST ORANGE. Eleva., 179.02 ft.
A cross cut in the southwest corner of the base of a polished column, standing on the right of the entrance to the Essex County Trust Company's building, which is on the southeast corner of Main Street and Arlington Avenue.

EAST ORANGE. Eleva., 180.52 ft.
A cross cut in the extreme southwest corner of the top step of the most westerly entrance to the First Reformed Church, which stands on the southeast corner of Main and Halsted Streets. This bench mark is vertically below the cross at the peak of the roof.

EAST ORANGE. Eleva., 184.08 ft.
A cross cut in the northwest corner of the base of the most westerly of four columns standing in front of the People's Bank, which is located at the southwest corner of Main and Prospect Streets.

GLEN RIDGE. Eleva., 194.63 ft.
A cross cut in the west end of the stone sill of the most westerly window, on the south or Bloomfield-avenue side of the High School building, which is at the northwest corner of Bloomfield and Ridgewood Avenues.

GLEN RIDGE. Eleva., 187.09 ft.
A cross, with the letters "B. M." cut in the north end of the brownstone coping of the west wall of the arch bridge, which carries Ridgewood Avenue over Second River. This bridge is about 150 feet from Bloomfield Avenue.

GLEN RIDGE. Eleva., 226.10 ft.
A cross cut in the east end, inside of the hand rail, of the north abutment (at the junction with the east wing wall) of the iron bridge which carries the Parkway over Second River and the Delaware, Lackawanna and Western Railroad.

MAPLEWOOD. Eleva., 130.27 ft.
A cross cut in the extreme west end of the north wing wall of the west abutment of a bridge which carries Parker Avenue over the East Branch of the Rahway River.

MAPLEWOOD. Eleva., 118.40 ft.
A cross cut in the east end of the north wing wall of the east abutment of the bridge which carries Oakland Avenue over the East Branch of the Rahway River.

MAPLEWOOD. Eleva., 109.77 ft.
A cross cut in the west end of the coping of the north wing wall of the east abutment of the bridge which carries Baker Avenue over the East Branch of the Rahway River.

MAPLEWOOD. Eleva., 133.86 ft.
A cross cut in the west end of the doorsill, of the only entrance, on the south or rear side, to the first or main floor of the public school building, which stands on the south side of Baker Avenue, just east of the Delaware, Lackawanna and Western Railroad.

MAPLEWOOD. Eleva., 97.35 ft.
A cross cut in a level place at the west end of the coping of the north wing wall of the west abutment of the bridge which carries Milburn Avenue over the East Branch of the Rahway River.

MILBURN. Eleva., 133.10 ft.
A cross cut in the east end of the coping of the north parapet of the arch bridge which carries Milburn Avenue over the Rahway River, in Milburn.

MILBURN. Eleva., 131.55 ft.
A cross cut in the south end (6 inches from the outer edge) of the doorsill of the Main-street entrance to the banking department of the First National Bank building.

MILBURN. Eleva., 146.24 ft.
A cross cut in the southwest corner of the stone base (near the east street curb) upon which rests the middle of three iron pillars supporting the east end of the bridge which carries the Delaware, Lackawanna and Western Railroad over Main Street.

MONTCLAIR. Eleva., 240.54 ft.
A cross cut in the north wall (near the southwest corner of a concrete post, measuring 2.7 feet x 1.2 feet) at the east end of the concrete bridge which carries Bloomfield Avenue over the Delaware, Lackawanna and Western Railroad. The concrete post is at the junction of the north parapet with the northeast retaining wall.

MONTCLAIR. Eleva., 250.53 ft.
A cross cut in the extreme west end of the stone doorsill (5 inches from a pilaster and near the junction of the west stone balustrade with the building) at the Bloomfield-avenue entrance to the Telephone building, which is on the southwest corner of Bloomfield and Gates Avenues.

MONTCLAIR. Eleva., 296.64 ft.
A cross cut in the northwest corner of the base of the most easterly of two columns standing in front of the Bank of Montclair building, which is located at 491 Bloomfield Avenue, on the north side of the street and about 180 feet west of North Fullerton Avenue. The column, on the base of which the cross is cut, stands between two windows.

MONTCLAIR. Eleva., 298.19 ft.
A cross cut in the east end of the base of a pilaster (4.3 feet from doorway and 1.5 feet above the sidewalk) on the east or left of Bloomfield-avenue entrance to the Young Men's Christian Association building.

MONTCLAIR. Eleva., 333.01 ft.
A cross cut in the south end of the water table (3.25 feet north of pilaster and 2 feet above the ground) on the west or Bell Street side of the Public Service car barns, which stand at the northeast corner of Bloomfield Avenue and Bell Street.

NEWARK. Eleva., 15.84 ft.
A cross cut in the fourth step from the bottom (or the eleventh step from the top) on the south end of the west abutment of the bridge which carries the Lehigh Valley Railroad over Frelinghuysen Avenue.

NEWARK. Eleva., 12.65 ft.
A cross cut in the east end of the doorsill of the Fenwick-avenue entrance to Engine House No. 19 of the Newark Fire Department, which stands on the northeast corner of Frelinghuysen and Fenwick Avenues.

NEWARK. Eleva., 24.62 ft.
A cross cut in the south end of the doorsill of the front entrance to the German Methodist Church, at the northeast corner of Walnut and Mulberry Streets.

NEWARK, Eleva., 38.47 ft.
A cross cut in the west end of the middle step of three at the Academy Street entrance to the Newark Post Office, which stands on the northwest corner of Broad and Academy Streets. The cross is 6 inches from west wall, 4 inches from back, and 8 inches from edge of step.

NEWARK. Eleva., 41.68 ft.
A cross cut in the water table of the Newark City Hall, about 13.5 feet above the street, 2⅓ feet above the platform of approach, $18^{11}/_{12}$ feet south from the south edge of the most southerly entrance, and 10½ inches north of the junction of the south stone balustrade with the building.

NEWARK. Eleva., 68.07 ft.
A cross cut in the northeast corner of the square marble base of the most northerly of two columns at the north, or left side, of the Hight Street entrance to the Essex County Courthouse. The courthouse is in the triangle formed by junction of High and Market Streets with Springfield Avenue.

NEWARK. Eleva., 109.92 ft.
A cross cut in a brownstone base at the foot of the north end of the east truss of the bridge which carries Summit Street over the Morris Canal, at the upper end of the inclined plane.

NEWARK. Eleva., 119.10 ft.
A cross cut in the northeast corner of the stone on which the east end of the north truss rests, in the end of the east abutment of the bridge which carries Sussex Avenue over the Morris Canal.

NEWARK. Eleva., 132.93 ft.
A cross cut in the south end of the brownstone doorsill of the Jay-street entrance to the First Infantry Armory, which stands on the south side of Central Avenue between Jay and Hudson Streets. This cross is 2½ inches from the south wall of the entrance, 5 inches from edge of sill and 8 inches from door jamb.

NEWARK. Eleva., 120.11 ft.
A cross cut in the southeast corner of the base of the column against the south wall of the building (four feet back from the corner column) of Engine House No. 15 of the Newark Fire Department, which stands on the north side of Park Avenue, between Sixth and Seventh Streets. The cross is on the northeast column of three, at the entrance to the building.

NEWARK. Eleva., 117.61 ft.
This bench mark is the pointed top of a concrete post in the middle of the south parapet of the concrete bridge which carries Bloomfield Avenue over a driveway and stream in Branch Brook Park.

NEWARK. Eleva., 117.58 ft.
This bench mark is the pointed top of a concrete post in the middle of the north parapet of the concrete bridge carrying Bloomfield Avenue over a driveway and stream in Branch Brook Park.

NEWARK. Eleva., 120.13 ft.
A cross cut in the north end of the east abutment (near the east end of the north truss) of the bridge which carries the Orange Branch of the Erie Railroad over the Morris Canal at Forest Hill. The cross is 2.83 feet from the end of truss, 3 inches from edge and 5.42 feet from the northwest corner of the abutment.

NEWARK. Eleva., 103.52 ft.
A cross cut in the north end of the doorsill of the most southerly entrance (near circular tower) to Tiffany and Company's factory, opposite Forest Hill Station of the Greenwood Lake Branch of the Erie Railroad.

NEWARK. Eleva., 187.52 ft.
A cross cut in the north end of the stone doorsill of the most southerly Seventh-street entrance of Fire House No. 11 of the Newark Fire Department, which stands on the northeast corner of Central Avenue and Seventh Street.

ORANGE. Eleva., 195.68 ft.
This bench mark is the extreme northeast corner of the base of the Soldiers' and Sailors' Monument, standing at the junction of Main and South Main Streets, at the intersection of Prince Street.

ORANGE. Eleva., 191.04 ft.
A cross cut in the west end of the doorsill of the Main-street entrance to the Young Men's Christian Association building, which stands on the north side of Main Street, east of Park Street. The entrance is at the west end of the building.

ORANGE. Eleva., 184.64 ft.
A cross cut in the south end of the sill, on Center Street side, of the corner window, formerly an entrance to the Public Service building, which stands on the southeast corner of Main and Center Streets.

ORANGE. Eleva., 190.74 ft.
A cross cut in the southeast corner (0.35 foot from wall, 0.55 foot from end and 3.35 feet from a stone lamp post) of the stone platform at the left of the entrance of the Orange National Bank, which is located one door east of the southeast corner of Main and Cone streets.

ORANGE. Eleva., 196.42 ft.
A cross cut on the west end of the doorsill of the main, or middle, entrance (directly under the steeple) of the First Presbyterian Church, which stands on the northwest corner of Main and Day Streets.

ORANGE Eleva., 219.84. ft.
This bench mark is a point on the extreme northwest corner of the base of the monument to the "Dispatch Rider of the American Revolution." This monument stands on the northeast corner of the cemetery, at the southwest corner of Main and Scotland Streets.

ORANGE. Eleva., 187.27 ft.
A cross cut in the south end of the doorsill of the left entrance to the waiting rooms of the Highland Avenue Station of the Delaware, Lackawanna and Western Railroad.

SOUTH ORANGE. Eleva., 168.95 ft.
A cross cut in the south end of the coping of the west wall of an arch bridge which carries Scotland Street over a small brook, about 125 feet north of South Orange Avenue.

SOUTH ORANGE. Eleva., 193.15 ft.
This bench mark is a point taken on the east end of doorsill (close to outer edge and 6 inches from east wall of doorway) of the rear entrance from South Orange Avenue to the First Presbyterian Church. This church stands on the point formed by the junction of South Orange and Irvington Avenues with Academy Street.

SOUTH ORANGE. Eleva., 189.70 ft.
A cross cut in the extreme west end of a stone sill (at a point where it projects from the surface of the wall) of the most westerly window on the north side of the first ell, or wing, north from First Street, of the Columbia School building, which stands on the west side of and facing Academy Street, between Irvington avenue and First Street. There are three wings running back from the main building with two courts. The windowsill on which the bench mark was left is in the rear of the school building on the court side of the first wing north of First Street.

South Orange. Eleva., 154.82 ft.
A cross cut in the concrete foundation, on the Vose Avenue side, between the corner show window and a column supporting the southeast corner of the Decker Building, which stands on the northwest corner of South Orange and Vose Avenues.

South Orange. Eleva., 137.91 ft.
A cross cut in a shelf (7.5 feet above the river and 1.3 feet below the foot path of the bridge upon which rests the east end of I-beam) on the north end of the east abutment of the bridge which carries South Orange Avenue over the East Branch of the Rahway River. There is also another cross cut in the west end of the north wing wall of the east abutment, 1.25 feet higher. This cross is directly above the bench mark, and must not be confused with it.

Springfield. Eleva., 105.34 ft.
This bench mark is a point on the southeast corner of the base (close up to the column or shaft) of a statute of a Continental soldier standing in the southwest corner of the Presbyterian Churchyard, on the northeast corner of Morris Avenue and Main Street.

Springfield. Eleva., 100.45 ft.
A cross cut in the top of a milestone marked "5½ miles to Elizabeth Town," which is 4.1 feet high, 1.5 feet wide and 0.7 feet thick, and stands at the junction of Morris Avenue and Seven Bridge Road.

Springfield. Eleva., 89.59 ft.
This bench mark is the top of the keystone of the most easterly of three arches, on the south side of an arch bridge which carries Morris Avenue over the West Branch of the Rahway River.

Springfield. Eleva., 105.99 ft.
A cross cut in the east end of the south wing wall of the west abutment of the bridge which carries Morris Avenue over a raceway, four-fifths of a mile west of the Presbyterian Church and at west junction of Morris Avenue with an old road.

Wyoming. Eleva., 100.44 ft.
A cross cut in the coping, 5 feet from the east end of the north parapet, of an arch bridge wihch carries a road leading from Milburn Avenue to Headleytown over East Branch of Rahway River. This road joins Milburn Avenue 200 feet east of the junction of Ridgewood Road and Milburn Avenue. The bridge is 350 feet southeast from Milburn avenue.

HUDSON COUNTY.

Harrison. Eleva., 26.03 ft.
A cross cut in the west end of the stone sill of the front door of the small brick office building, at Peter Hauck and Company's brewery, on Harrison Avenue, opposite Washington Street.

Harrison. Eleva., 31.67 ft.
A cross cut near the southeast corner of the base of the column standing at the right, or east side of the front entrance to the West Hudson Trust Company's building, on the north side of Harrison Avenue, just west of Kearny Avenue.

Harrison. Eleva., 55.42 ft.
A cross cut in the east end of the south abutment, on a shelf (2.9 feet below the footpath) upon which rests the south end of the east truss, of the bridge which carries Kearny Avenue over the Erie Railroad.

Jersey City. Eleva., 94.93 ft.
A cross cut in the south corner of the upper large square stone step at the main entrance (on Summit Avenue) of the Westminster Presbyterian Church, at the east corner of Summit and Magnolia Avenues.

JERSEY CITY. Eleva., 99.65 ft.
A cross cut in the east end of the sandstone sill of the most westerly of two doors in the Newark Avenue front of the Hudson County Jail, opposite Oakland Avenue.

JERSEY CITY. Eleva., 101.22. ft.
A cross cut in the south end of the doorsill (ten inches from the door jamb, 3.6 inches from the south side of the entrance and 1.3 feet from the outer edge of the sill) of the most easterly of three entrances from Newark Avenue to the Hudson County Courthouse, which stands on the west corner of Newark and Pavonia Avenues.

JERSEY CITY. Eleva., 26.25 ft.
A cross cut in the north end of the east abutment, at the foot of the east end of the north truss of a small viaduct which carries a 30-inch water main over the tracks of the West Shore or Junction Railroad, just south of the bridge carrying Newark Avenue over the same railroad.

JERSEY CITY. Eleva., 18.65 ft.
A cross cut in the north side of the stone base of the fifth, or last pilaster from Montgomery Street, on the Washington-street side of the Union Trust Company's building, which stands on the southwest corner of Montgomery and Washington Streets.

JERSEY CITY. Eleva., 6.99 ft.
A cross cut in the top of the south wall of Morris Canal lock No. 22. The cross is 14.1 feet from the head, or drop gate, 20.4 feet from the stone steps leading to the street and 0.12 foot from the edge of the wall. This lock is at Washington Street.

KEARNY. Eleva., 121.81 ft.
A cross cut in the first of two steps (0.7 foot from southwest corner of step, 15.5 feet from junction of the west wing wall with the northwest corner of the bridge, and 3.4 feet below the roadbed) in the west end of the north abutment of the bridge which carries Kearny Avenue over the Greenwood Lake Branch of the Erie Railroad, about 1,500 feet west from Arlington Station.

KEARNY. Eleva., 110.24 ft.
A cross cut in the southeast corner of the large stone landing, five steps down from the door, of the entrance to the Town Hall. This cross is in the corner formed by the junction of the south stone balustrade with the building. The Town Hall stands on the east side of Kearny Avenue nearly opposite Grove Street.

NEW DURHAM. Eleva., 7.91 ft.
A cross cut in the lowest of a series of steps (near the edge and close up to the bottom of the next step above) of the north abutment of the bridge which carries the Hackensack Turnpike over the West Shore Railroad at the station.

MORRIS COUNTY.

BOONTON. Eleva., 412.94 ft.
A cross cut in the east corner of the coping stone, level with the railroad, at the north corner of the Delaware, Lackawanna and Western Railroad bridge over the Rockaway River.

BOONTON. Eleva., 485.73 ft.
A cross on the southwest corner of the third stone of the shaft foundation of the soldiers' monument on Main Street. The point is at the top of the curved edge and 2 inches below the base of the shaft.

BOONTON. Eleva., 494.77 ft.
A cross cut in the east end of the granite sill of the east door of the Maxfield Engine House, 713 Main Street.

BOONTON. Eleva., 494.15 ft.
A cross cut in the east end of the north concrete parapet, under iron fence one foot west, of the west end of the wing wall of the Pond Bridge, which carries Main Street over the Rockaway River, above the falls.

CHATHAM. Eleva., 242.84 ft.
A cross cut in the sixth coping stone from the north end, in the center of the east parapet of the Delaware, Lackawanna and Western Railroad bridge over the Passaic River. This coping stone is 6 feet long by 3 feet wide. The cross is 26.1 feet from the north end and 45.6 feet from the south end of the east parapet.

CHATHAM. Eleva., 234.16 ft.
A cross cut in the west end of the sill (2 inches from the edge, 3½ inches from the brick wall and 10 inches from the door saddle) at the entrance to the Mayor's Office and Library at the west end of the Town Hall, which stands on the north side of Fairmount Avenue between the Delaware, Lackawanna and Western Railroad and Main Street.

CHATHAM. Eleva., 261.97 ft.
A cross cut in the stone parapet on the east side of the steps leading to the front entrance of the public school building, which stands on the north side of Fairmount Avenue just west of the Delaware, Lackawanna and Western Railroad. The parapet measures 4 feet by 2.7 feet; the cross is 0.7 foot from the side of the building, 3.3 feet from end of the parapet and 2 feet from the pilaster just east of the entrance.

CHATHAM. Eleva., 209.29 ft.
A cross cut in the north post of the west wall of an arch bridge which carries Main Street over a small stream at the junction of Main and Lafayette Streets.

DENVILLE. Eleva., 503.42 ft.
A cross in the granite corner stone, at the west end of the south abutment of the iron bridge which carries a road over Rockaway River. The bridge is 2 miles northeast of Denville Station and 300 feet south of the junction of the Rockaway Valley road with the Rockaway-Boonton (Cook's) road.

DENVILLE. Eleva., 512.86 ft.
A cross cut in the northeast corner of the stone on the top of the south wall of Morris Canal Lock, No. 8, right at the end of the gate, when open.

DENVILLE. Eleva., 505.75 ft.
A cross cut in the south end of the granite coping of the west abutment of the two-span iron bridge which carries the Denville-Piers Lock road over the Rockaway River. This bridge is about a mile north of Denville Station.

DENVILLE. Eleva., 508.77 ft.
This bench mark is on the north abutment of the bridge of the Rockaway branch of the Delaware, Lackawanna and Western Railroad which crosses Den Brook, half a mile north of Denville Station. This point is on the outside corner of the third step from the top of the east end of the abutment.

DENVILLE. Eleva., 515.40 ft.
A cross cut in the bluestone sill of the basement window in the front or west of the building in the ell to the north of the main entrance to the public school.

DOVER. Eleva., 558.64 ft.
A cross in the surface (15 inches south of the northwest corner) of the west concrete sidewalk of the bridge carrying Mercer Street over Rockaway River. This cross is 3 inches east of the west parapet of the bridge.

DOVER. Eleva., 572.99 ft.
A cross cut in the water table at the southeast corner of George Richard's brick building at the northwest corner of Blackwell and Sussex Streets.

DOVER. Eleva., 582.08 ft.
A cross cut in the top and in the northeast corner of the bluestone forming the west side of the bottom step of the main front entrance to the Memorial Presbyterian Church. This mark is close to the base of the chimes tower.

DOVER. Eleva., 571.09 ft.
A cross cut in the top of the granite stone at the top of the wing wall at the northwest corner of the bridge which carries Sussex Street over the Rockaway River.

DOVER. Eleva., 574.02 ft.
A cross cut in the southeast corner of the brownstone sill of the east entrance to the High School which stands on the corner of McFarland and Sussex Streets.

DOVER. Eleva., 537.81 ft.
A cross cut in the outside corner on top of the granite stone forming the north end of the west bridge seat of the girder bridge which carries the Hibernia Mine Railroad over Rockaway River.

LAKE HOPATCONG. Eleva., 925.68 ft.
A cross cut in the northeast corner of the north end of the west wall of the raceway of the Morris Canal lock at the outlet of the lake. This is also a canal bench mark.

LAKE HOPATCONG. Eleva., 908.20 ft.
A cross cut in the top and in the southwest corner of the second step from the top of the west end of the north abutment of the bridge which carries the Delaware, Lackawanna and Western Railroad (cut off) over the Landing and Port Morris road.

LAKE JUNCTION. Eleva., 682.49 ft.
A cross cut in the southeast corner of a large granite stone under the concrete cap of the bridge seat at the south end of the west abutment of the bridge which carries the Delaware, Lackawanna and Western Railroad over Rockaway River, $1^1/_8$ miles west of Wharton Station.

LAKE JUNCTION. Eleva., 711.98 ft.
A cross cut in the top and in the southwest corner of the south concrete parapet of the four-track bridge which carries the Delaware, Lackawanna and Western Railroad over the Lake Hopatcong Branch of the Central Railroad of New Jersey, 1¾ miles west of Wharton Station.

LANDING. Eleva., 933.50 ft.
A cross cut in the northeast corner of the bluestone sill of the front entrance of the block house office building of W. E. King, on the south side of the Landing road.

LANDING. Eleva., 936.55 ft.
A cross in the west end of the south concrete parapet of the concrete bridge, which carries the highway over the Delaware, Lackawanna and Western Railroad and the Morris Canal, about 100 feet west of Hopatcong station. The bench mark is above the west springing line of the arch and 13.5 feet higher and at the east end of the concrete guard.

LANDING. Eleva., 939.67 ft.
A cross cut in the southwest corner of the concrete sill of the west main entrance to the Lake Hopatcong station of the Delaware, Lackawanna and Western Railroad, on the west side of tracks. The bench mark is 1 foot above the road level.

LINCOLN PARK. Eleva., 182.48 ft.
A cross cut in the southwest corner of the stone forming the upper step at the east end of the north wall of Morris Canal lock No. 12, east.

LINCOLN PARK. Eleva., 184.13 ft.
A cross cut in the south end of the bluestone doorsill of the entrance to the public school house on the back river road to Two Bridges.

LINCOLN PARK. Eleva., 178.00 ft.
A cross cut in the south concrete platform of the Delaware, Lackawanna and Western Railroad station. The point is in close to the building at the middle of the south side below the window.

LINCOLN PARK. Eleva., 179.17 ft.
A cross cut in the north side of the foundation (directly over the "9" in "1906") of the water tower, 900 feet west of the Delaware, Lackawanna and Western Railroad station.

MADISON. Eleva., 197,56 ft.
A cross cut in the south end of the sill of the most southerly of the windows in the west side of the Madison Water Works pumping station.

MADISON. Eleva., 205.34 ft.
A cross cut in the west end of the coping of the south parapet of the culvert which carries Main Street over Spring Garden Brook just east of the junction of Main Street and Rosedale Avenue.

MADISON. Eleva., 227.56 ft.
A cross cut in the east end of the sill (near the middle pilaster) of the most westerly window in the front of the brick office and apartment building of Green and Pierson, which stands on the south side of Main Street between Prospect Street and Waverly Place. This point is on the sill of the window to the left of the front entrance to the apartment at the west end of the building.

MADISON. Eleva., 243.77 ft.
A cross cut in the southwest corner of the bluestone platform of the approach to the front entrance to the banking department of the Madison Trust Company's building, which stands on the southwest corner of Main Street and Waverly Place. The point is near the wall and south of the base of the column against the wall at the left of the entrance.

MADISON. Eleva., 252.06 ft.
A cross cut in the east end of the doorsill of the Main Street entrance to the Young Men's Christian Association, on the corner of Main Street and Park Avenue.

MONTVILLE. Eleva., 239.57 ft.
A cross cut in the summit of a very large rounded boulder imbedded in the towpath at the edge of the Morris Canal, 200 yards east of the lower plane.

MONTVILLE. Eleva., 387.87 ft.
A cross cut in a projecting stone on the top of the wall at the south side of the square well into which the water falls, at the top of the upper plane of the Morris Canal.

MONTVILLE. Eleva., 311.55 ft.
A cross cut in the south end of the bluestone doorsill of the main entrance to the Town Hall.

MONTVILLE. Eleva., 316.52 ft.
A cross cut in the northeast corner of the concrete doorsill of the main front entrance to the public school.

MORRISTOWN. Eleva., 403.56 ft.
A cross cut in the east end of the sill, close by the west side, of the most easterly of two wooden pillars at the entrance of the Morris County Courthouse.

MORRISTOWN. Eleva., 376.66 ft.
This bench mark is on the flat surface, directly under the carved stone cannon, at the west corner of the base of the soldiers' monument in the city park.

MORRISTOWN. Eleva., 369.72 ft.
A cross cut in the southwest corner of the middle granite step (6 inches below the water table), of the Methodist Episcopal Church, on Park Place.

MORRISTOWN. Eleva., 366.95 ft.
A cross cut in the south end of the bluestone doorsill of the southerly entrance from Speedwell Avenue to the Police Headquarters building, on the corner of Speedwell Avenue and Water Street.

MORRISTOWN. Eleva., 373.83 ft.
A cross cut in the southeast end of the granite step (at the level of the granite doorsill and 6 inches above the sidewalk) of the First National Bank building on Park Place. The point is at the base of the ornamental stone door jamb of iron grill.

MOUNT TABOR. Eleva., 502.06 ft.
A cross cut in the northwest corner of the coping of the wall over the north end of a culvert, under the Morris and Essex Railroad, for carrying off the overflow of a pond, 1 mile east of Mount Tabor.

MT. ARLINGTON. Eleva., 782.84 ft.
A cross cut in the southeast corner of the south concrete parapet of the bridge which carries the Delaware, Lackawanna and Western Railroad over the Kenville-Mt. Arlington road. The bridge is 600 feet west of the station.

NETCONG. Eleva., 874.13 ft.
A cross cut in the northeast corner of the bluestone sill of the entrance at the east end of Stanhope-Netcong station of the Delaware, Lackawanna and Western Railroad.

PORT MORRIS. Eleva., 892.66 ft.
A cross cut in west end of bluestone sill of the basement window on the north side of the tower of the Methodist Episcopal Church.

PORT MORRIS. Eleva., 890.18 ft.
A cross cut in the south end of the bluestone sill of the south basement window on the east side of the public schoolhouse.

POWERVILLE. Eleva., 494.31 ft.
A cross cut in the west end of the bluestone doorsill of the north entrance to the concrete engine-house, of Field, White & Company's paper mills.

POWERVILLE. Eleva., 495.53 ft.
A cross cut in the south end (at the end of two trusses) of the bluestone top of the center pier supporting the two spans of the highway bridge over the Rockaway River, at the paper mills.

ROCKAWAY. Eleva., 523.18 ft.
This bench mark is on the northeast corner of the flange of the cast-iron footplate at the northeast corner of the iron bridge over the Morris Canal, at the foot of the plane.

ROCKAWAY. Eleva., 527.50 ft.
A cross cut in the outside corner of the north end of the west abutment of the Main Street bridge over the Rockaway River.

ROCKAWAY. Eleva., 533.63 ft.
A cross cut in the east end of a bluestone doorsill of the easterly Main-street entrance to the municipal building.

ROCKAWAY. Eleva., 563.87 ft.
This bench mark is a point taken on the northeast corner of the flat portion of the top of the bluestone sill of the east front window of Strait's store, on Main Street. The bench mark is indicated by an arrow cut in the flagging about 4 inches below the point.

SHIPPENPORT. Eleva., 873.54 ft.
The bottom of a square hole cut in the west end of the bridge seat of the south concrete abutment of the four track Delaware, Lackawanna and Western Railroad bridge over Morris Canal.

SHIPPENPORT. Eleva., 874.78 ft.
A cross cut in the southeast corner of the wrought iron bedplate of the south end of the east girder of the four track Delaware, Lackawanna and Western Railroad bridge over the highway.

SHIPPENPORT. Eleva., 864.57 ft.
A cross cut in the southeast corner of the east coping stone of the north wing wall of the overflow on the east side of the Morris Canal, a short distance north of the Delaware. Lackawanna and Western Railroad.

TOWACO. Eleva., 226.56 ft.
A cross cut in the west end of the doorsill of the entrance near the west end and on the south side of the Delaware, Lackawanna and Western Railroad station.

TOWACO. Eleva., 243.39 ft.
A cross cut in the top of a brownstone block which forms the northeast corner of the foundation of the Methodist Episcopal Church, which stands near the tracks and about 1,000 feet east of the Delaware, Lackawanna and Western Railroad station.

TOWACO. Eleva., 224.11 ft.
A cross cut in the west abutment of the bridge which carries the Delaware, Lackawanna and Western Railroad over the highway west of the station. The point is on the concrete bridge seat, 4 feet below the track level, and 3 feet north of the north rail.

TOWACO. Eleva., 194.46 ft.
A cross cut in the northwest corner of the bridge seat of the west concrete topped abutment of the bridge which carries the Delaware, Lackawanna and Western Railroad over a road at the foot of plane No. 10 east. This point is one foot south of the north end of the abutment, 3 feet below, and 25 feet north of the north rail of the two track line.

WHARTON. Eleva., 612.60 ft.
A cross cut in the outside corner of the upper step at the north end of the western abutment of the Delaware, Lackawanna and Western Railroad bridge over the Rockaway River, three-quarters of a mile southeast of Wharton.

WHARTON. Eleva., 602.35 ft.
A cross cut in the outside corner of the lowest step at the south end of the western abutment of the bridge which carries the High Bridge Branch of the Central Railroad of New Jersey over the Rockaway River, three-quarters of a mile southeast of Wharton.

WHARTON. Eleva., 666.25 ft.
A cross cut in the west end of the south abutment of the bridge which carries the High Bridge Branch of the Central Railroad of New Jersey over the Delaware, Lackawanna and Western Railroad. This cross is cut on the granite stone at the end of the bridge seat.

WHARTON. Eleva., 694.96 ft.
A cross cut in the top of and in the south end of the bluestone sill of the Main-street entrance of Wharton Public School.

PASSAIC COUNTY.

ATHENIA. Eleva., 183.78 ft.
A cross cut in the northeast corner of the west abutment at the north end of the bridge which carries the highway leading from Athenia Station on the Delaware, Lackawanna and Western Railroad, to Montclair, over the Morris Canal.

ATHENIA. Eleva., 179.50 ft.
This bench mark is on a small cut in a projecting stone, 4.6 feet above the ground, at the west end of the north abutment of the road bridge over the Morris Canal, 1 mile south of Athenia. The point is indicated by an arrow head.

ATHENIA. Eleva., 164.80 ft.
A cross cut in the southeast corner of the west end of the culvert which carries a highway leading from Athenia Station (Erie R. R.) to Montclair, over a small stream, about 800 feet northeast from the Morris Canal.

HAWTHORNE. Eleva., 41.83 ft.
A cross cut in the top of the granite coping (6 inches back from the southeast corner) of the east wing wall of the north abutment of the bridge which carries the Erie Railroad over the Passaic River. The point is 5 feet below the track level.

LITTLE FALLS. Eleva., 174.67. ft.
A cross cut in the stone coping at the end of the iron railing on the west side of the Passaic River, of the Morris Canal aqueduct.

LITTLE FALLS. Eleva., 194.90 ft.
A cross cut in the northwest corner of the stone doorsill of the main front entrance of the Reformed Church.

LITTLE FALLS STATION (TOTOWA). Eleva., 194.56 ft.
This bench mark is at the point of an arrow on the water table at the northeast corner of the Little Falls depot of the Delaware, Lackawanna and Western Railroad.

MOUNTAIN VIEW. Eleva., 172.62 ft.
A cross cut in the top of the north concrete wing wall (9 inches back from the north corner) of the east abutment of the bridge which carries the highway over the Pompton River. This bridge is 800 feet west of the Erie Railroad Station and 300 feet south of the Morris Canal aqueduct.

MOUNTAIN VIEW. Eleva., 175.74 ft.
A cross cut in the north corner of the west end of the coping of the circular wall at the north end of the west abutment of the aqueduct by which the Morris Canal crosses the Pompton River.

MOUNTAIN VIEW. Eleva., 180.57 ft.
A cross cut in the east end of the concrete doorsill of the south entrance of the Delaware, Lackawanna and Western Railroad station.

PASSAIC. Eleva., 56.69 ft.
A cross cut in the south end of doorsill of the front entrance of the Passaic Trust and Safe Deposit Company's building, which stands on the west side of Main Street between Academy and Bloomfield Avenues.

PASSAIC. Eleva., 60.31 ft.
A cross cut in a raised projection, in front of the wall, on the extreme south end of the doorsill of the entrance to the municipal building standing on the northwest corner of Howe Avenue and Prospect Street. This entrance is between two fire engine rooms.

PASSAIC. Eleva., 26.51 ft.
A cross cut in the extreme southwest corner of the west end of the coping of the north wall of the arch bridge which carries Passaic Avenue over the tailrace from the mills. This bridge is a short distance west of the New York, Susquehanna and Western Railroad.

PATERSON. Eleva., 99.45 ft.
A cross cut in the south end of the Main-street entrance to St. Boniface Church, at the southeast corner of Main and Slater Streets.

PATERSON. Eleva., 80.12 ft.
A cross cut in the east end of the doorsill of the main front entrance to the Market Street M. E. Church.

PATERSON. Eleva., 88.82 ft.
A cross cut in the west end of the doorsill of the main entrance to the municipal building on the corner of Market and Union Streets.

PATERSON. Eleva., 99.15 ft.
A cross cut in the north end of the doorsill of the main entrance to the First Presbyterian Church, on the corner of Main and Ward Streets.

PATERSON. Eleva., 103.18 ft.
A cross cut in the top of the second cheek stone from the bottom, at the northwest corner of the base of the second pillar from the north end of the Hamilton-street entrance to the Passaic County Courthouse.

PATERSON. Eleva., 181.24 ft.
This point is on the East Jersey Water Company's bench mark at Stony road reservoir, Grand Street and Reservoir Avenue, and is a cross cut in outcrop rock, one foot north of the concrete wall on the Grand-street side and 36 feet east of the middle of the intake pipes near the corner of the streets.

PATERSON. Eleva., 187.69 ft.
A cross cut in the north corner of the concrete facing of the east abutment of the Delaware, Lackawanna and Western Railroad bridge over the Passaic River, known as High Bridge. This bridge is between Paterson and Little Falls.

RICHFIELD. Eleva., 182.56 ft.
A cross cut in the north end of the east abutment of the bridge over the Morris Canal. The point is at the end of the timber on which the bridge rests.

RICHFIELD. Eleva., 183.11 ft.
A cross cut in the east end of the bluestone sill of the window, between cornerstone marked "1907," and the main entrance to St. John's German Lutheran Church.

RICHFIELD. Eleva., 186.72 ft.
This bench mark is the bottom edge of the corner-stone, marked "1907," of St. John's German Lutheran Church.

RICHFIELD. Eleva., 191.84 ft.
A cross cut in the east end of the bluestone sill of the front basement window, nearest the east side, of Public School No. 2.

TOTOWA. See Little Falls Station.

SUSSEX COUNTY.

ANDOVER. Eleva., 638.05 ft.
This bench mark is on the large gneiss rock on the bank, on the east side of the Sussex Railroad, 145 yards north of the station and 9 yards north of cattle pens.

ANDOVER. Eleva., 648.15 ft.
A cross cut in the top of the north end of bluestone sill of the middle one of three basement windows of the bell tower of the Methodist Episcopal Church. Window is on west side of tower.

ANDOVER. Eleva., 611.84 ft.
This bench mark is indicated by an arrow on the top of a brownstone corner-stone at the southwest corner of the Presbyterian Church.

ANDOVER JUNCTION. Eleva., 579.16 ft.
A cross cut in the northwest corner of the bed-plate at the south end of the west girder of the bridge carrying the Sussex Branch of the Delaware, Lackawanna and Western Railroad over the Pequest River, just north of Andover Junction.

BRANCHVILLE. Eleva., 526.77 ft.
A cross cut in the center and 1 foot from the west edge of a large stone in the top course on the west end of the north abutment of the Sussex Branch of the Delaware, Lackawanna and Western Railroad bridge over Dry Brook, 25 yards south of crossing over the railroad of the road to Augusta, and southeast of the entrance of the road to Swartswood. (The bench is not on the single stone which is upon the top of the wall.)

BRANCHVILLE. Eleva., 578.04 ft.
A cross cut in the northeast corner of a limestone corner-stone inscribed "Presbyterian Church of Branchville A. D. 1856." This stone is set in east side of building in the middle one of three attached pillars.

BRANCHVILLE. Eleva., 573.93 ft.
The top of exposed corner-stone bearing inscription Branchville M. E. Church 1864–78. Point is indicated by an arrow.

BRANCHVILLE. Eleva., 535.16 ft.
A cross cut in the northwest corner of bed-plate at north end of west girder of Delaware, Lackawanna and Western Railroad bridge over Dry Brook just south of station and northeast of Borden's creamery.

BRANCHVILLE JUNCTION. Eleva., 577.25 ft.
A cross cut in the top surface of the concrete foundation just south of the "9" in 1905 of the pipe homing of the Delaware, Lackawanna and Western Railroad water tower on the west side of the track and south of the station.

BRANCHVILLE JUNCTION. Eleva., 560.67 ft.
This bench mark is on the east side of the Sussex Branch of the Delaware, Lackawanna and Western Railroad and the north rail of the New York, Susquehanna and Western Railroad at their crossing.

CARPENTER'S POINT. Eleva., 452.30 ft.
This bench mark is the top of State line monument on the road which runs from Port Jervis to Montague.

CARPENTER'S POINT. Eleva., 421.36 ft.
This bench mark is the top of the State line monument on the east shore of the Neversink River.

CARPENTER'S POINT. Eleva., 480.93 ft.
This bench mark is on the State line monument on the east side of the turnpike to Deckertown, at the Two-States Hotel.

CARPENTER'S POINT. Eleva., 414.99 ft.
This bench mark is on the Tri-State monument at the meeting of the boundary lines of New Jersey, New York and Pennsylvania, on the extreme point at the forks of Delaware and Neversink Rivers.

COLEVILLE. Eleva., 908.30 ft.
A cross cut in the large boulder at the entrance of the road to Sand Pond about 1 mile northwest of Coleville.

COLEVILLE. Eleva., 807.87 ft.
A cross cut in face of 1887 corner-stone of the M. E. Church just below and between the two "8's". Elevation is at intersection of cross.

COLEVILLE. Eleva., 781.28 ft.
A cross cut in the top of the west end of the south girder of highway bridge over the brook 200 feet west of the school house. Mark is about 6 inches west of the west face of west iron rail post.

CULVER'S GAP. Eleva., 915.35 ft.
This bench mark is on the summit of a conglomerate boulder on the northeast corner of the roads meeting in the gap.

CRANBERRY LAKE. Eleva., 777.05 ft.
The summit of the most westerly of the two spurs of gneiss rock at the northeast corner of the road from Stanhope and a road running northeast at the north end of the Cranberry Reservoir (not marked).

CRANBERRY LAKE. Eleva., 766.73. ft.
A cross cut in top of west coping, directly over keystone, of the stone arch culvert over the brook 400 yards south of Cranberry Station. The coping is the only course of masonry above the arch, and the mark is 2.80 feet higher than the crown of the arch.

EMMONS. Eleva., 468.77 ft.
A cross cut in the top of limestone that is at the northwest end of the bridge seat of the southwest abutment of girder bridge No. $^{78}/_{26}$, carrying the New York, Susquehanna and Western Railroad over the Freedon-Middleville road, and a brook. The point is 1 foot back from the exposed corner of the stone.

FRANKLIN FURNACE. Eleva., 560.13 ft.
This bench mark is on the stone water table at the southwest corner (front corner towards New Furnace) of the company's brick store and office.

FRANKLIN FURNACE. Eleva., 565.91 ft.
A cross cut in the north end of the limestone sill of the front entrance of the Catholic Church. The building is of limestone and was built in 1902.

FRANKLIN FURNACE. Eleva., 557.49 ft.
A cross cut in the northwest end of the granite sill of the front entrance to the public school.

HAINESVILLE. Eleva., 639.29 ft.
A cross cut in the top of an imbedded rock with rounded summit, on the east side of the road, 40 yards north of the corner of roads, at which the church and schoolhouse stands.

HAINESVILLE. Eleva., 651.83 ft.
A cross cut in surface of the concrete porch of the Dutch Reformed Church. This point is on the north end of the northerly of the two front entrances.

HAINESVILLE. Eleva., 660.15 ft.
A cross cut in the white limestone corner-stone, bearing the inscription "M. E. Church 1911," at the southeast corner of the building. This mark is on the flat surface back under the baseboard.

HALSEY. Eleva., 609.28 ft.
A cross cut in the south coping (1 foot from the east end) of the concrete culvert (Nos. 68-14) just west of Halsey Station of the New York, Susquehanna and Western Railroad.

HALSEY. Eleva., 576.53 ft.
A cross cut in the surface, 1 foot from northeast end, of coping of northwest concrete wall of culvert No. $^{69}/_{00}$ carrying New York, Susquehanna and Western Railroad over a brook 1 mile southwest of Halsey Station.

HIGH POINT. Eleva., 1800.21 ft.
This bench mark is the highest point of the bed-rock on the summit of the mountain.

HIGH POINT. Eleva., 1804.30 ft.
This bench mark is a cross cut on the top of a boulder on the summit of the mountain. This is the highest point in New Jersey.

LAFAYETTE. Eleva., 549.94 ft.
This bench mark is on the summit of a limestone boulder, indicated by an arrow, at the east corner of the main crossroads in the village.

LAFAYETTE. Eleva., 512.60 ft.
A cross cut in the southeast corner of the limestone on top of the south abutment on the east side of the Sussex Railroad track, where it crosses above the wagon road, just east of the crossroads and about 1 mile north of the village.

MONTAGUE. Eleva., 520.82 ft.
A cross cut in the rought stone water table near the bar room door of the Brick House Hotel.

MONTAGUE. Eleva., 527.22 ft.
A cross cut in top surface of concrete abutment, close to the girder, about 1 foot south of the north end of west girder of small road bridge just south of the Brick House Hotel. The bench mark, which is at the elevation of the bottom of the girder, is also indicated by an arrow cut in the lower flange of the girder, near its edge.

NEWTON. Eleva., 648.68 ft.
A cross cut in the east end of the outside of the limestone doorsill at the entrance of the Sussex County Courthouse.

NEWTON. Eleva., 650.02 ft.
This bench mark is indicated by an arrow cut in the granite of the lowest of the stepped stones forming the base of the Soldiers' Monument. The point is at the highest part of the northwest corner of the lowest stone directly at the base of the second stone.

NEWTON. Eleva., 656.56 ft.
A cross cut in top and at north end of limestone sill of main entrance of Newton Trust Company's building.

NEWTON. Eleva., 649.63 ft.
A cross cut in the east end of the limestone sill of the north door of the Clerk's and Surrogate's office building.

NEWTON. Eleva., 678.46 ft.
A cross cut in the east end of the stone doorsill at the corner of the jamb of the entrance to the Presbyterian Church.

NEWTON. Eleva., 601.24 ft.
A cross cut in the limestone sill of the most northerly of three doors (baggage room) in the east side of the Newton station of the Sussex Railroad.

NEWTON. Eleva., 602.36 ft.
A cross cut in the northwest corner of the bedplate at the south end of the west girder of the single track bridge carrying the Sussex branch of the Delaware, Lackawanna and Western Railroad over the road leading from Newton to Mulford Station, at Drake's Pond, 1 mile south of Newton.

STANHOPE. Eleva., 864.15 ft.
A cross cut in the outside corner of the coping at the west end of the north wall of the Morris Canal lock, at outlet of the reservoir. This is a canal bench mark.

STANHOPE. Eleva., 958.53 ft.
A cross cut in the south end of bluestone sill of basement window facing west, in L at west of south entrance to High School.

SWARTSWOOD STATION. Eleva., 502.58 ft.
A cross cut in the top, about 1 foot back from the outside corner, of the first limestone step below the bridge seat, at the northwest end of the northeast masonry abutment of the track bridge carrying the New York, Susquehanna and Western Railroad over the Newton road.

STILLWATER. Eleva., 476.30 ft.
A cross cut in the second limestone step from the top at the northwest end of the southwest abutment of small field culvert (No. $^{74}/_{17}$) 275 yards northeast of the creamery and 1 mile northeast of station.

STILLWATER. Eleva., 471.31 ft.
A cross cut in a small shelf on the northeast side, 6 inches below the summit of a 5-foot white limestone boulder on the northwest side of the New York, Susquehanna and Western Railroad at the southwest end of the retaining wall of the cut, 650 yards northeast of the station.

STILLWATER. Eleva., 460.39 ft.
A cross cut in the southeast end of the concrete doorsill of the entrance at the southwest end of the McDermott creamery.

SUSSEX. Eleva., 440.92 ft.
A cross cut in the south end of the stone doorsill of the brick store building on the northwest corner of the streets, on the south corner of the open triangle opposite Goble's Hotel.

SUSSEX. Eleva., 482.37 ft.
A cross cut in the south end of the bluestone sill of the basement window near the south end of the west side of the Public School.

SUSSEX. Eleva., 419.31 ft.
A cross cut in the bluestone porch of the First Baptist Church. The point is near the west end of the westerly of the two front entrances.

TUTTLE'S. Eleva., 756.87 ft.
This bench mark is on the summit of a large boulder on the northwest corner of the roads meeting about three-quarter mile south of Tuttle's Corner.

WARBASSE. Eleva., 559.22 ft.
A cross cut in surface of the south end of west concrete abutment, 1 foot back from face of the abutment and 1 foot north of the angle line of the abutment and wing wall of single track bridge carrying the New York, Susquehanna and Western Railroad over Paulinskill just west of station.

WATERLOO. Eleva., 652.79 ft.
A cross cut in the outside corner of gneiss rock forming the top of south end of west abutment of highway bridge over outlet of Waterloo Pond, 200 yards below dam. It is an iron bridge and near foot of canal plane.

WATERLOO. Eleva., 653.57 ft.
A cross cut in east end of lowest bluestone step of the stone stairs leading up from the road to the level of church yard at the Methodist Church. The point is 6 inches north of outside face of retaining wall.

WATERLOO. Eleva., 642.71 ft.
A cross cut in the middle of the piece of the bluestone cap of the east parapet that is directly over the middle pier of the two-span masonry arch highway bridge (Kinney's bridge) over the Musconetcong River 1 mile west of Waterloo.

WHITEHALL. Eleva., 705.58 ft.
This bench mark is on a small rounded summit, marked by an arrow on the coping stone, 2 inches back from the face of the wall and directly over the center of the keystone of the east side of the stone arch bridge carrying the Sussex Railroad over the wagon road, just north of Whitehall and about 1 mile south of Andover.

UNION COUNTY.

ELIZABETH. Eleva., 32.83 ft.
This bench mark is a point taken on the northeast corner of the third step from the top (to the right and in the rear as the monument faces) of the Soldiers' and Sailors' Monument, which stands in a triangle formed by the intersection of North Broad, Prince and Magnolia Streets.

ELIZABETH. Eleva., 30.44 ft.
A cross cut in the south end of the stone sill of the main front door of the First Presbyterian Church.

ELIZABETH. Eleva., 27.74 ft.
A cross cut in the southeast corner of the bottom step of the series of steps of the east retaining wall of the north abutment of the bridge which carries the Pennsylvania Railroad over West Jersey Avenue. This bench mark is at the foot of a stairway leading to the south end of the east platform of the railroad station.

ELIZABETH. Eleva., 31.02 ft.
A cross cut in the extreme south end of the stone platform of the entrance to the Union County Courthouse, on the west side of South Broad Street opposite Elizabeth Avenue. There are four fluted columns at the entrance, with their bases resting on the platform. The cross is cut in front of the most southerly of the four columns and near the pilaster at the south side of the entrance.

ELIZABETH. Eleva., 14.29 ft.
A cross cut in coping, 1.55 feet north of a line perpendicular to the center of the keystone of the middle arch, of the east parapet of an arch bridge which carries South Broad Street over the Elizabeth River.

ELIZABETH. Eleva., 38.71 ft.
This bench mark is on the cross on top of a property monument at the northeast corner of Linden Avenue and the road leading to Lorraine. This bench mark is about 1½ miles southwest of Elizabeth.

LINDEN. Eleva., 19.83 ft.
A copper bolt set in the northeast wing wall of the northwest abutment of a bridge which carries the Pennsylvania Railroad over Morse's Creek, about 1¼ miles east of Linden. This is probably a railroad bench mark. It is marked thus: $\overset{22}{([.])}$

LINDEN. Eleva., 18.08 ft.
A cross cut in the southeast corner of the south end of the east abutment of a bridge which carries the Baltimore and Ohio Railroad over Linden Avenue, about 1¼ miles east of Linden. This bench mark is 4.2 feet above the ground.

LINDEN. Eleva., 35.03 ft.
A cross cut in the south corner of the southeast end of bridge seat of the northeast concrete abutment of a bridge which carries the Pennsylvania Railroad over Wood Avenue.

LINDEN. Eleva., 23.36 ft.
A cross cut in the center of the middle coping stone of the northwest parapet of an arch bridge which carries Linden Avenue over the South Branch of Morse's Creek, about 1¼ miles west of the station.

LINDEN. Eleva., 26.42 ft.
A cross cut in the south end of the east abutment of the concrete bridge which carries the Pennsylvania Railroad over Stiles Street, 700 yards west of the station.

RAHWAY. Eleva., 18.17 ft.
A cross cut at the foot of the lamp post end of the iron railing on west end of the coping of the north parapet of an arch bridge which carries Elizabeth Avenue over Rahway River.

RAHWAY. Eleva., 18.81 ft.
A cross cut in the stone foundation at the northwest corner of the Second Presbyterian Church. A niche in the buttress at this corner exposes the foundation for an area about 6 inches square; on this is the cross.

RAHWAY. Eleva., 24.42 ft.
A cross cut in the stone base of the pilaster (between the entrance and the most southerly window) on the west side of the Rahway National Bank, which is on Irving Street just west of its junction with Lewis Street.

RAHWAY. Eleva., 20.18 ft.
A cross cut in the east end of the north abutment of a bridge which carries the Perth Amboy Branch of the Pennsylvania Railroad over the South Branch of the Rahway River, 1⅓ miles west of station.

RAHWAY. Eleva., 11.96 ft.
A cross cut in the southwest corner of a stone in the west end of the north abutment, which supports the north foot of the west truss, of a bridge which carries Georges Avenue over the South Branch of the Rahway River. This bridge is about 1 mile west of Rahway and is on the line between Union and Middlesex Counties.

SUMMIT. Eleva., 194.63 ft.
This bench mark is the highest point on the extreme west corner of the keystone in the south end of the arch of a bridge which carries Springfield Avenue over a small stream, about 1¼ miles east of Summit. This stream empties into a pond south of the road.

SUMMIT. Eleva., 227.70 ft.
A cross cut in the east end of coping of the south wall of a culvert which carries Morris Avenue over a small stream. This culvert is about 150 feet west of the junction of Springfield and Morris Avenues.

SUMMIT. Eleva., 261.93 ft.
A cross cut in the east end of coping of the south wall of a small culvert which carries Morris Avenue over a small waterway between Orchard Street and the turnpike.

SUMMIT. Eleva., 324.19 ft.
A cross cut in the southwest corner of the concrete base of the east iron pillar of the two pillars on the north side of the road, supporting the bridge which carries the Rahway Valley Railroad over Morris Avenue.

SUMMIT. Eleva., 390.61 ft.
A cross cut in the east end of the bridge seat of the south concrete abutment of a bridge which carries Summit Avenue over the Delaware, Lackawanna and Western Railroad, just east of the station. This point is 1.3 feet from the end and 1.47 feet from the edge of the abutment, 1.5 feet from back wall and 3.5 feet below the platform of the bridge.

SUMMIT. Eleva., 393.66 ft.
A cross cut in the east end of the stone sill of the window in the middle arch in the front of the Municipal Building on Springfield Avenue near the corner of Summit Street.

SUMMIT. Eleva., 396.35 ft.
A cross cut in the west end of the doorsill of the side entrance, on Springfield Avenue, of the Summit Bank building, on the northeast corner of Springfield and Beechwood Avenues. This is the entrance to apartments above the banking rooms.

SUMMIT. Eleva., 382.07 ft.
A cross cut in a concrete retaining wall, at change of level, near the west end of south abutment of a bridge which carries Springfield Avenue over the Delaware, Lackawanna and Western Railroad.

SUMMIT. Eleva., 260.25 ft.
A cross cut in the bridge seat (0.55 foot from bed plate of truss) at east end of south concrete abutment of a bridge which carries the Delaware, Lackawanna and Western Railroad over the Boulevard.

WARREN COUNTY.

BELVIDERE. Eleva., 257.40 ft.
The top of a copper bolt, around which a square is cut, set in a limestone block at the northwest end of the northeast bridge seat of field bridge (P. R. R.) No. 87, just northeast of the railroad bridge over the highway, 1⅛ miles southwest of station. This is a railroad bench mark.

BELVIDERE. Eleva., 290.45 ft.
A cross cut in the north end of the granite sill of the southerly of the two entrances on the west side of the public school.

BELVIDERE. Eleva., 289.88 ft.
Cross cut in the northeast corner of the brownstone sill of the middle, or tower door of the First Presbyterian Church, which stands on the west side of the city park.

BELVIDERE. Eleva., 286.01 ft.
A cross cut in the west end of the brownstone doorsill of the Surrogate's office. This is the most westerly of the four doors in the front of the Warren County Courthouse.

BELVIDERE. Eleva., 265.44 ft.
A copper bolt around which a square is cut, set in t[illegible] dressed stone, on which rests the south end of the west girder of the single track (P. R. R.) bridge, No. 91. The bolt is 6 inches northeast of the corner of the bedplate.

BELVIDERE. Eleva., 262.36 ft.
A copper bolt, around which a square is cut, set in a limestone block in the northwest coping of the Pennsylvania Railroad stone arch bridge over the brook, 300 yards south of the station. This bolt is in the top surface of the coping and above the crown of the arch of bridge No. 88.

BELVIDERE. Eleva., 286.00 ft.
The bottom of a square cavity cut in the west end of the bluestone sill of the door of the County Clerk's Office; said door being the easterly of the four doors in the front of the courthouse.

BELVIDERE. Eleva., 287.03 ft.
A cross cut in top and at the north end of the brownstone sill of the main front entrance of the Methodist Episcopal Church, on the east side of the park.

BLAIRSTOWN. Eleva., 349.73 ft.
A cross cut in the southwest corner of the upper of two square dressed granite blocks, on which rests the east end of the south truss of the single track bridge (No. [illegible]), carrying the New York, Susquehanna and Western Railroad over Paulinskill. This bridge is three-fourths miles east of the station.

BLAIRSTOWN. Eleva., 347.38 ft.
A cross cut in the west end of the doorsill of the tower entrance to the Presbyterian Church.

BLAIRSTOWN. Eleva., 346.13 ft.
A cross cut in the west end of doorsill of the entrance to the People's National Bank.

BLAIRSTOWN. Eleva., 348.03 ft.
A cross cut in the square limestone base of the most easterly of the three pillars in front of the First National Bank.

BROADWAY. Eleva., 350.56 ft.
A cross cut in the top and east end of the north concrete parapet of the bridge which carries the turnpike over Mill Brook. The point is 6 inches above concrete floor of bridge.

BROADWAY. Eleva., 351.93 ft.
A cross cut in the east end of the concrete doorsill of the tower entrance to Broadway Methodist Episcopal Church.

BROADWAY. Eleva., 345.84 ft.
This bench mark is the top of the seventh course of brick of the chimney on the west side of the schoolhouse. The top of this course is above the bottom of the woodwork of the building. The point is marked by an arrow on the face of the chimney towards the road, and near the southwest corner.

BROADWAY. Eleva., 434.73 ft.
This bench mark is on the southwest corner of a square-dressed stone (2½ feet from the wooden sill lying thereon) at the south side of the floodgate of the Morris Canal, just south of the road leading from Broadway to Montana.

BUTTSVILLE. Eleva., 346.47 ft.
A cross cut in the northwest corner of the south abutment of the iron bridge which carries the highway over Pequest River, 1 mile west of the railroad station. The stone is a conglomerate.

BUTTSVILLE. Eleva., 382.24 ft.
A cross cut in the northwest corner of the top surface of the bedplate at the north end of the west truss of the bridge, which carries the highway over Pequest River, 225 yards east of the Lehigh and Hudson River Railroad.

BUTTSVILLE. Eleva., 382.70 ft.
A cross in a circle cut in the northwest concrete wing wall (at the end of the lattice guard rail) of the truss bridge which carries the highway over Pequest River east of the station.

BUTTSVILLE. Eleva., 423.40 ft.
A cross cut in the outer edge of the coping stone on the south side of the Delaware, Lackawanna and Western Railroad track, and directly over the keystone of the center arch of the stone bridge over the Pequest River and the Lehigh and Hudson River Railroad, east of Buttsville station.

COLUMBIA. Eleva., 294.77 ft.
A cross cut in the southeast corner of the square dressed granite block on which rests the west end of the south truss of the single track bridge which carries the New York, Susquehanna and Western Railroad over Paulins Kill. This bridge is one-half mile east of Columbia.

COLUMBIA. Eleva., 308.91 ft.
A cross cut in the east end of the bluestone sill of the basement window in the front of the M. E. Church, and just west of the tower.

COLUMBIA. Eleva., 310.53 ft.
The bottom of the corner-stone inscribed "M. E. Church, 1840–1892." The point is at the exposed corner.

COLUMBIA. Eleva., 286.69 ft.
A cross cut in the northwest corner of the bedplate at the east end of the north truss of the bridge which carries the highway over Paulins Kill at its mouth.

DELAWARE. Eleva., 284.67 ft.
A cross cut in the northwest corner of the bedplate at the southeast corner of the two-track, five-span bridge, which carries the Delaware, Lackawanna and Western Railroad over the Delaware River, 1 mile north of Delaware. The mark is on the new or northerly bridge.

DELAWARE. Eleva., 288.34 ft.
The top of stone slab in front of the Presbyterian Church.

DELAWARE. Eleva., 290.47 ft.
This bench mark, indicated by an arrow, is at the bottom of the middle of front face of corner-stone (without inscription) at the southeast corner of St. James Church.

EASTON, PA., U. S. C. S. Eleva., 214.401 ft.
This bench mark is the bottom surface of a square cavity cut on top of a pier (north side of the New Jersey Central Railroad track) of the bridge across the Lehigh River at Easton. It is on the pier at the west end of wide part of bridge. It is marked thus: B |U. S. / XIX| M

EASTON, PA., U. S. C. S. Eleva., 357.186 ft.
This is the bottom of a square cavity cut in the foundation stone at west corner of the jail at Easton. The front of the jail is built of red sandstone and the foundation of blue limestone.

EASTON, PA., U. S. C. S. Eleva., 363.488 ft.
This bench mark is the bottom surface of a square cavity cut on the sill of a blind window on the east side of Easton Courthouse. This side of the courthouse has two blind windows, but the one used is the one nearest to the front of the building. It is marked thus: U. S. C. & G. S. B |H / 1881| M

EASTON, PA. Eleva., 196.55 ft.
A cross cut in the southeast corner of the post-office building, which stands at corner of Ferry and Second streets. The front is an alcove between the two sides at base of corner pillar and level with the top step at the entrance.

EASTON, PA. Eleva., 235.10 ft.
A cross cut in the northwest corner of the granite sill under the outer arch of the main entrance of the public school building.

FOUL-RIFT. Eleva., 252.02 ft.
A cross cut 8 inches back from the outside corner (at the north end) on the concrete wall over the arch at the west end of the concrete road culvert No. 84, 400 yards south of the railroad station. The mark is on the top face of wall and is about 6.6 feet higher than and 8 inches north of the crown of the arch. This culvert is south of the highway culvert.

HACKETTSTOWN. Eleva., 567.67 ft.
A cross cut in the northeast corner of the northeast concrete pier of the pipe housing of the water tower, just east of the Delaware, Lackawanna and Western Railroad Station.

HACKETTSTOWN. Eleva., 570.37 ft.
Bluestone water table at the northeast corner of the Peoples National Bank.

HACKETTSTOWN. Eleva., 562.60 ft.
A cross cut in the southeast end of the brownstone sill of the entrance to the Hackettstown National Bank.

HACKETTSTOWN. Eleva., 553.82 ft.
A cross cut in the southeast end of the brownstone sill of the lower entrance of the Methodist Episcopal Church.

HACKETTSTOWN. Eleva., 556.05 ft.
A cross cut in the east corner of the bluestone sill of the southerly Washington-street entrance of the public school.

HACKETTSTOWN. Eleva., 597.63 ft.
This bench mark is on the sandstone water table at the base of the brick work, at the northeast corner of the main building (directly over the cornerstone dated "Dec. 1, 1900") of the Centenary Collegiate Institute (unmarked).

HACKETTSTOWN. Eleva., 573.06 ft.
A cross cut in the southwest corner of the granite stone on which rests the west end of the south girder of the bridge which carries the Delaware, Lackawanna and Western Railroad over the turnpike just south of Warren Furnace. Stone referred to is on the bridge seat of west abutment.

HAINESBURG. Eleva., 329.03 ft.
This bench mark is the bottom of the corner-stone (at the exposed corner) of the church marked "M. E. Church, A. D. 1892." The point is indicated by an arrow.

HAINESBURG. Eleva., 306.43 ft.
A cross cut in the limestone at the east end of the south abutment of the southerly of the two iron highway bridges. The point is 1 foot west of the angle of the abutment and wing wall.

HARMONY STATION. Eleva., 199.65 ft.
A cross cut in the northeast corner of the fourth sandstone step from the bottom, on the east wing wall of the south abutment of the stone arch bridge which carries the Pennsylvania Railroad over a farm road to the river. The bridge (No. 72) is just south of mile post 14/54 and is locally known as Arney's culvert.

HARMONY STATION. Eleva., 216.25 ft.
The northeast corner of a sandstone post about 9 inches square, set 6.7 feet west of the west rail of the single track, on the Belvidere Branch of the Pennsylvania Railroad, 300 yards south of the station and 350 yards north of mile post 18/54. The stone is marked: J B 4/09 (the east face is marked: 54).

HARMONY STATION. Eleva., 215.69 ft.
This bench mark is the bottom of a slot 4 inches long, ½ inch wide (formed by a drill hole) 4 inches north of the southeast corner of the top of the square dressed granite stone on which rests the north end of the west girder of railroad bridge No. 77, 550 yards north of the station.

HAZEN. Eleva., 409.72 ft.
A cross cut in the northeast corner of the projecting foundation stones at the southeast corner of the brick Presbyterian Church, at Oxford Church. The point is at the southeast corner of the attached brick column that rests on the stones.

HUTCHINSON. Eleva., 219.34 ft.
A cross cut in the top and at the outside corner of the northeast end of the sandstone coping over the arch at the southwest end of stone culvert No. 80 which carries the single track of the Belvidere Branch of the Pennsylvania over Buckhorn Creek, about 175 yards west of the station.

HUTCHINSON. Eleva., 225.76 ft.
A cross cut in the southwest corner of the south wall (over the crown of the arch) of a stone culvert which carries the Pennsylvania Railroad over a farm road to the Delaware River. This culvert is 100 yards east of mile post 9/59 and about 0.6 miles west of the station. The stone is a speckled sandstone 6 feet above and 10 feet west of the crown of the bridge.

LOPATCONG. Eleva. 262.986 ft.
This bench mark is the bottom surface (center) of a square cavity cut in the coping stone at the east end of the north parapet of the stone bridge of the Central Railroad of New Jersey, over the Morris Canal, about 1½ miles east of Phillipsburg. It is marked thus: B | ‾‾ | M.
1881

LOPATCONG. Eleva., 218.95 ft.
A cross cut in the summit of the most westerly stone in the coping of the north wall of the upper lock of the Morris Canal.

MARKSBORO. Eleva., 422.70 ft.
The highest point (indicated by an arrow cut in the top surface) of the exposed spigot end of an iron pipe at the northwest end of a flood culvert, with concrete end walls, under the New York, Susquehanna and Western Railroad, 1½ miles northeast of the station. (Bridge No. $^{79}/_{24}$.)

MARKSBORO. Eleva., 402.66 ft.
A cross cut in the west corner of the bedplate at the northeast end of the northwest truss of the bridge which carries the New York, Susquehanna and Western Railroad over Paulins Kill, three-fourths miles northeast of the station.

MARKSBORO. Eleva., 393.58 ft.
A cross cut on limestone (1 foot back from the exposed corner) at the northeast end of the northwest abutment of the highway bridge over the Paulins Kill at the station.

MARKSBORO. Eleva., 371.45 ft.
A cross cut in the south corner of the square dressed granite stone on which rests the east end of the south truss of the New York, Susquehanna and Western Railroad bridge over Paulins Kill. This bridge is No. $^{80}/_{27}$ and is 1 mile west of the station.

MARTIN'S CREEK. Eleva., 226.95 ft.
Top of bolt, around which a square is cut, set in a granite stone in the top of the east side of the circular wall of the turntable at the east end of the railroad bridge over the Delaware River at Martin's Creek.

MARTIN'S CREEK. Eleva., 219.95 ft.
A cross cut in the southeast corner of the higher part of the most easterly of the five stone piers supporting the railroad bridge over the Delaware River. There are two bridge rests on this pier, the mark being on the easterly and higher one.

MARTIN'S CREEK. Eleva., 324.15 ft.
A cross cut in the northeast end of the concrete sill of the basement window, that is in the northwest side of the part of the public school building, on which the bell tower is, and which contains the hall of the main front entrance.

NEW VILLAGE. Eleva., 435.36 ft.
A cross cut in the rounded summit of the coping stone on the west side of the south wall of the Morris Canal lock, west of the village. The summit is 1.5 feet from the end of the wall, and about 3 yards from the tail-gates.

NEW VILLAGE. Eleva., 374.95 ft.
A cross cut in the surface of concrete porch of Thatcher's store. The mark is about 2 feet east of the northwest corner of the porch and directly north of the coal chute. This building is on the turnpike, at the old Stewartsville road.

NEW VILLAGE. Eleva., 439.98 ft.
A cross cut in the northeast corner of the east bedplate of the north truss, on the east concrete abutment of the bridge which carries the trolley road on Morris Canal.

NEW VILLAGE. Eleva., 426.87 ft.
A cross cut in the east end of the south concrete parapet of a small highway bridge over the canal feeder that is just west of the canal lock, 1 mile west of the village.

OXFORD FURNACE. Eleva., 479.77 ft.
A cross cut in the east end of the stone sill of the front door of the Oxford Iron and Nail Company's brick store, on the north corner of the streets, just south of the railroad station.

OXFORD FURNACE. Eleva., 501.84 ft.
A cross cut in the south end of the stone doorsill of the front door of the Second Presbyterian Church.

OXFORD FURNACE. Eleva., 570.42 ft.
A cross cut in the granite water table at the north end of the doorsill of the public school.

PAULINA. Eleva., 346.78 ft.
A cross cut in the bluestone coping of the east end of the north abutment (the one nearest the railroad) of the highway bridge over Paulins Kill.

PEQUEST FURNACE. Eleva., 439.32 ft.
Bottom of a square cavity cut in the top surface of the granite stone at the north end of the west coping of the Delaware, Lackawanna and Western Railroad stone arch culvert, 1½ miles north of Oxford Furnace Station. This culvert is over Furnace Brook.

PHILLIPSBURG. Eleva., 207.87 ft.
A cross cut in the southwest corner of the lowest step (close to the bottom of the second step) of the east wing wall of the north abutment of the girder bridge which carries the Lehigh Valley Railroad over South Main Street, just west of Center Street.

PHILLIPSBURG. Eleva., 215.18 ft.
This bench mark is the bottom of a square cavity cut 6 inches back from the southwest corner of the fourth from the top, of the square dressed stones forming the series of steps of the south wing wall, of the east abutment of a two-track bridge which carries the Central Railroad of New Jersey over the Delaware River, just north of the Lehigh Valley Railroad bridge. The point is on a sandstone block and its top surface is 2.5 feet above the bridge seat.

PHILLIPSBURG. Eleva., 232.60 ft.
A cross cut in the east end of the bluestone doorsill of the Main-street entrance to the Second National Bank, at the corner of Main and Market Streets.

PHILLIPSBURG. Eleva., 195.56 ft.
A cross cut in the northwest corner of the stone water table under the column on the east side of the north entrance of the Pennsylvania Railroad station, at the east end of the cantilever highway bridge over Delaware River.

PHILLIPSBURG. Eleva., 194.21 ft.
A cross cut in the northwest corner of the square dressed sandstone coping of the north end of the east abutment (New Jersey side) of the cantilever bridge which carries the highway over the Delaware River, between Phillipsburg and Easton, Pa. The point is about the elevation of the concrete sidewalk of the bridge.

PHILLIPSBURG. Eleva., 197.60 ft.
A cross cut in the top of the concrete foundation at the northeast corner of the building (and east of the doors opening towards the turntable) of the Lehigh and Hudson River Railroad roundhouse, near the north end of the Phillipsburg freight yards.

PHILLIPSBURG. Eleva., 199.36 ft.
The top of a bolt head set in the sandstone coping near the middle of the west wall of the small stone road culvert at the north end of the Lehigh and Hudson River Railroad, Phillipsburg yards. A square is cut around the head of the bolt. This is a railroad bench mark.

PHILLIPSBURG. Eleva., 201.70 ft.
Head of a bolt set in a granite stone of the bridge seat near the west end of the north abutment of the single track girder bridge No. 70, which carries the Pennsylvania Railroad over a farm road. This bridge is just north of the mile post 18/58 and northeast of a small brick school house on the Pennsylvania side of the Delaware River. This is a railroad bench mark.

PLEASANT VALLEY. Eleva., 500.40 ft.
This bench mark is the top of the bottom course of brick at the southwest corner of the Pleasant Valley brick schoolhouse. The point is marked by a vertical arrow set in brick.

PORT COLDEN. Eleva., 569.98 ft.
This bench mark is on the southeast corner of the masonry at the gates of the flume, at the head of plane No. 6, west of Morris Canal.

PORT COLDEN. Eleva., 526.54 ft.
A cross cut in the east end of the granite doorsill of the main entrance to the brick schoolhouse.

PORT COLDEN. Eleva., 522.85 ft.
This bench mark is the top of the white limestone corner-stone of the church, inscribed "Port Colden M. E. Church 1893." Elevation taken at top of stone and at bottom of wooden baseboard.

PORT COLDEN. Eleva., 525.63 ft.
A cross cut in the southwest corner of the top granite step at the west end of the north abutment of the concrete bridge which carries the Hackettstown-Washington highway over the Delaware, Lackawanna and Western Railroad.

PORT MURRAY. Eleva., 644.54 ft.
A cross cut in the south end of the bluestone sill of the basement window just south of the triple memorial window, and north of the main entrance, of the McCrea Memorial M. E. Church.

PORT MURRAY. Eleva., 607.44 ft.
A cross cut in the northwest corner of the top granite step at the west end of the south abutment of the wooden bridge which carries the road over the Delaware, Lackawanna and Western Railroad, about 500 feet west of the station.

PORT MURRAY. Eleva., 630.99 ft.
This bench mark is on the north corner of masonry of the gates at the head of the flume of Morris Canal plane No. 5, west.

PORT WARREN. Eleva., 334.39 ft.
This bench mark is the southeast corner of the bottom step of a series forming the end of the foundation wall, at the southwest corner of the wheelhouse of Morris Canal plane No. 9, west.

PORT WARREN. Eleva., 281.05 ft.
A cross cut in the northeast corner of the dressed granite stone which forms the bottom step of the west wing wall at the north end of the double arch stone culvert which carries the highway and Lopatcong Creek under the Delaware, Lackawanna and Western Railroad.

PORT WARREN. Eleva., 280.04 ft.
A cross cut in the northeast corner of the bedplate at the northwest corner of the girder bridge which carries the turnpike over Lopatcong Creek. It is just east of the intersection of the turnpike with the Port Warren road.

ROCKPORT. Eleva., 648.55 ft.
A cross cut in the northeast corner of the stone porch of the Presbyterian Church. The point is on a granite stone, level with the bottom of the wooden baseboard.

ROXBURY STATION. Eleva., 244.20 ft.
The top of a copper bolt, around which a square is cut, set in a block of sandstone at the west end of a small girder bridge (No. 83) over the highway at the north end of the station. This is a railroad bench mark.

ROXBURY STATION. Eleva., 265.05 ft.
A cross cut in the southeast corner of the north abutment of a wooden truss bridge which carries the highway over the Belvidere Branch of the Pennsylvania Railroad, about 250 yards east of the station.

SAXTON FALLS. Eleva., 637.69 ft.
A cross cut in the coping of the west lock wall, just back of the middle of a groove for temporary repair dam, just above the chamber for the head gate of the Morris Canal guard lock No. 5, west.

SAXTON FALLS. Eleva., 618.71 ft.
A cross cut in top and northeast corner of a granite coping stone at the north end of the west abutment of the girder bridge which carries the Delaware, Lackawanna and Western Railroad over the Musconetcong River.

SAXTON FALLS. Eleva., 642.86 ft.
A cross cut in the corner of a stone in which the west tail-gate is anchored, close to the south side of the quoin, Morris Canal, lock No. 4.

SAXTON FALLS. Eleva., 605.65 ft
A cross cut in the northwest corner of a granite stone on top of the north end of the east abutment of the iron bridge over Mucsonetcong River. The point is 1½ feet below the bridge floor.

STEWARTSVILLE. Eleva., 405.83 ft.
A cross cut in the foundation at the east corner of the wheelhouse at the Morris Canal plane No. 8, west.

STEWARTSVILLE. Eleva., 341.51 ft.
A cross cut in the top of a limestone block, in which rests the post of the southeast end of the southwest iron rail of a small highway bridge (with concrete floor) southeast of the Stewartsville road bridge over the canal. The point is about 15 feet southeast of the middle of the bridge.

STEWARTSVILLE. Eleva., 333.68 ft.
A cross cut in the northwest corner of the concrete porch of the northerly of the two entrances of the brick schoolhouse. The point is close to the foundation and 6 inches lower than the bottom of the lowest course of brick.

STEWARTSVILLE. Eleva., 322.66 ft..
A cross cut in the top of the brownstone base on which rests the northerly of the two detached wooden columns at the front of the First Lutheran Church. The mark is at the southwest corner of the column.

STEWARTSVILLE. Eleva., 374.28 ft.
This bench mark is on the northeast corner of the square dressed stone on which the bedplate of the truss rests, at the south end of the east abutment of the Morris and Essex Railroad bridge over the Morris Canal, east of the station.

STEWARTSVILLE. Eleva., 320.40 ft.
A cross cut in the top surface of the brownstone cheek stone at the north end of the stone steps of the front entrance of the Presbyterian Church. The mark is at the level of the stone entrance floor and at the middle of the square wooden column which rests on the stone and which is attached to the building.

VAIL. Eleva., 345.95 ft.
A cross cut in the north face of a block of limestone set in the foundation at the northeast corner of the D. B. Kaiser gristmill, which stands opposite the station. Elevation is at the intersection of the cross and 0.58 feet below the bottom of baseboard.

VAIL. Eleva., 311.06 ft.
A cross cut in the top surface of the bluestone coping at the east end of the south abutment of the bridge which carries the Polkville-Walnut Valley highway over Paulins Kill, 1 mile west of Vail and at the cross-roads of the Walnut Valley-Polkville and Blairstown-Hainesburg roads. The bench mark is 7.0 feet above water level.

WASHINGTON. Eleva., 488.62 ft.
A cross cut in the east coping of the wing wall of the south abutment of the bridge which carries the Delaware, Lackawanna and Western Railroad over the highway, about 2 miles north of Washington Station. The mark is at the angle in the wall, 5.5 feet east of the east rail.

WASHINGTON. Eleva., 489.89 ft.
A cross cut in the north end of the brownstone doorsill of the main front entrance of the public school. The mark is by the corner of the brickwork.

WASHINGTON. Eleva., 485.53 ft.
A cross cut in the east end of the brownstone doorsill of the spire entrance (on Church street) of the Presbyterian Church.

WASHINGTON. Eleva., 508.08 ft.
This bench mark is on the northwest corner of the north end, on top of the wall supporting the wooden flume at the head of Morris Canal plane No. 7, west. The point is also a canal bench mark.

WASHINGTON. Eleva., 463.05 ft.
A cross cut in the southeast corner of the highest of three bluestone steps at the entrance of the First National Bank, on the northwest corner of Belvidere and Washington Avenues.

WASHINGTON. Eleva., 462.01 ft.
This bench mark is on the corner of a stone under the iron column at the northeast corner of the Beatty Building, which stands at the southwest corner of Belvidere and Washington Avenues.

WASHINGTON. Eleva., 467.54 ft.
This bench mark is on the stone water table of the Windsor Hotel, a brick building facing on Washington Avenue. The point is on the rear corner of a wing, with three windows, extending back from the main building on Belvidere Avenue.

PUBLICATIONS.

The appended list makes brief mention of all the publications of the present Survey since its inception in 1864, with a statement of the editions now out of print. The reports of the Survey are distributed without further expense than that of transportation. Single reports can usually be sent more cheaply by *mail* than otherwise, and requests should be accompanied by the proper postage as indicated in the list. Otherwise they are sent *express collect. When the stock on hand of any report is reduced to 200 copies, the remaining volumes are withdrawn from free distribution and are sold at cost price.*

The maps are distributed only by sale, at a price, 25 cents per sheet, to cover cost of paper, printing and transportation. In order to secure prompt attention, requests for both reports and maps should be addressed simply "State Geologist," Trenton, N. J.

CATALOGUE OF PUBLICATIONS.

GEOLOGY OF NEW JERSEY. Newark, 1868, 8 vo., xxiv+899 pp. Out of print.

PORTFOLIO OF MAPS accompanying the same, as follows:

1. Azoic and paleozoic formations, including the iron-ore and limestone districts; colored. Scale, 2 miles to an inch.
2. Triassic formation, including the red sandstone and trap-rocks of Central New Jersey; colored. Scale, 2 miles to an inch.
3. Cretaceous formation, including the greensand-marl beds; colored. Scale, 2 miles to an inch.
4. Tertiary and recent formations of Southern New Jersey; colored. Scale, 2 miles to an inch.
5. Map of a group of iron mines in Morris County; printed in two colors. Scale, 3 inches to 1 mile.
6. Map of the Ringwood iron mines; printed in two colors. Scale, 8 inches to 1 mile.
7. Map of Oxford Furnace iron-ore veins; colored. Scale, 8 inches to 1 mile.
8. Map of the zinc mines, Sussex County; colored. Scale, 8 inches to 1 mile.

A few copies can be distributed at $2.00 per set.

REPORT ON THE CLAY DEPOSITS of Woodbridge, South Amboy and other places in New Jersey, together with their uses for firebrick, pottery, &c. Trenton, 1878, 8vo., viii+381 pp., with map. Out of print.

A PRELIMINARY CATALOGUE of the Flora of New Jersey, compiled by N. L. Britton, Ph.D. New Brunswick, 1881, 8vo., xi+233 pp. Out of print

FINAL REPORT OF THE STATE GEOLOGIST. Vol. I. Topography. Magnetism. Climate. Trenton, 1888, 8vo., xi+439 pp. Out of print.

FINAL REPORT OF THE STATE GEOLOGIST. Vol. II. Part I. Mineralogy. Botany. Trenton, 1889, 8vo., x+642 pp. Unbound copies, postage, 25 cents. Bound copies, $1.50.

FINAL REPORT OF THE STATE GEOLOGIST. Vol. II. Part II. Zoology. Trenton, 1890, 8vo., x+824 pp. (Postage, 30 cents.)

REPORT ON WATER-SUPPLY. Vol. III. of the Final Reports of the State Geologist. Trenton, 1894, 8vo., xvi+352 and 96 pp. (Postage, 21 cents.)

REPORT ON THE PHYSICAL GEOGRAPHY of New Jersey. Vol. IV. of the Final Reports of the State Geologist. Trenton, 1898, 8vo., xvi+170+200 pp. Unbound copies, $1.00; cloth bound, $1.35, with photo-relief map of State, $2.85. Map separate, $1.50.

REPORT ON THE GLACIAL GEOLOGY of New Jersey. Vol. V. of the Final Reports of the State Geologist. Trenton, 1902, 8vo., xxvii+802 pp. (Sent by express, 35 cents if prepaid, or charges collect.)

REPORT ON CLAYS AND CLAY INDUSTRY of New Jersey. Vol. VI. of the Final Reports of the State Geologist. Trenton, 1904, 8vo., xxviii+548 pp. (Price, $1.60.)

REPORT ON IRON MINES AND MINING in New Jersey. Vol. VII. of the Final Report of the State Geologist. Trenton, 1910, 8vo., xv+512 pp., with two maps in a separate envelope. (Postage, 25 cents.)

BRACHIOPODA AND LAMELLIBANCHIATA of the Raritan Clays and Greensand Marls of New Jersey. Trenton, 1886, quarto, pp. 338, plates XXXV. and Map. (Paleontology, Vol. I.) (To residents of New Jersey, by express, charges collect; to non-residents, $1.50, charges prepaid.)

GASTEROPODA AND CEPHALOPODA of the Raritan Clays and Greensand Marls of New Jersey. Trenton, 1892, quarto, pp. 402, Plates L. (Paleontology, Vol. II.) (To residents of New Jersey, by express, charges collect; to non-residents, $1.40, charges prepaid.)

PALEOZOIC PALEONTOLOGY. Trenton, 1903, 8vo., xii+462 pp., Plates LIII. (Paleontology, Vol. III.) (Price, $1.00.)

CRETACEOUS PALEONTOLOGY. Trenton, 1907, 8vo., ix+1106 pp., Plates CXI. (Paleontology, Vol. IV.) (Price, $2.70.)

ATLAS OF NEW JERSEY. The complete work is made up of twenty sheets, each about 27 by 37 inches, including margin. Seventeen sheets are on a scale of 1 inch per mile and three on a scale of 5 miles per inch. Sheets numbered 21 to 37 replace old sheets numbered 1-17, which cannot longer be furnished. These sheets each cover the same territory as eight of the large maps, on a scale of 2,000 feet per inch.

No. 19. New Jersey Relief Map. Scale, 5 miles to the inch. Hypsometric.

No. 20. New Jersey Geological Map. Scale, 5 miles to the inch. (Out of print.)

No. 21. Northern Warren and Western Sussex counties. Replaces Sheet 1.

No. 22. Eastern Sussex and Western Passaic counties. Replaces Sheet 4.

No. 23. Northern Bergen and Eastern Passaic counties, to West Point, New York. Replaces northern part of Sheet 7.

No. 24. Southern Warren, Northern Hunterdon and Western Morris counties. Replaces Sheet 2.

No. 25. Morris and Somerset counties, from Lake Hopatcong to Somerville and New Brunswick. Replaces Sheet 6.

No. 26. Vicinity of Newark and Jersey City—Paterson to Perth Amboy. Replaces in part Sheet 7.

No. 27. Vicinity of Trenton—Raven Rock to Palmyra, with inset, Trenton to Princeton. Replaces Sheet 5.

No. 28. Trenton and Eastward—Trenton to Sayreville. Replaces Sheet 8.

No. 29. Monmouth Shore, with the interior from Ernston to Lakehurst. Replaces Sheet 9.

No. 30. Parts of Gloucester and Salem counties, from Paulsboro on the north, to Quinton and Deerfield on the south, with adjacent portions of Pennsylvania and Delaware.

No. 31. Vicinity of Camden, to Mount Holly, Hammonton and Elmer. Replaces Sheet 11.
No. 32. Part of Burlington and Ocean counties, from Pemberton and Whitings to Egg Harbor City and Tuckerton. Replaces Sheet 12.
No. 33. Southern Ocean County—Tuckerton to Tom's River and Chadwicks. Replaces Sheet 13.
No. 34. Western Cumberland county, including Bridgeton, with Delaware bay and adjacent portion of Delaware.
No. 35. Vicinity of Millville, from Newfield to Port Norris and Cape May Court House.
No. 36. Parts of Atlantic and Cape May counties—Egg Harbor City to Townsend's Inlet, with inset of New Inlet and Great Bay.
No. 37. Cape May—Cape May City to Ocean City and Mauricetown.
No. 38. New Jersey State Map. Scale, 5 miles to the inch. Shows all municipalities. (Out of print.)

All the maps are sold at the uniform price of twenty-five cents per sheet, either singly or in lots. Since the Survey cannot open small accounts, and the charge is merely nominal, remittance should be made with the order. Order by *number* of the State Geologist, Trenton, N. J.

TOPOGRAPHIC MAPS, NEW SERIES.

These maps are the result of revision of the earlier surveys, and contain practically all of the features of the one-inch per mile maps, with much new material. They are published on a scale of 2,000 feet to an inch, and the sheets measure 26 by 34 inches. The Hackensack, Paterson, Boonton, Dover, Jersey City, Newark, Morristown, Chester, New York Bay, Elizabeth, Plainfield, Pluckemin, Amboy, New Brunswick, Somerville, Navesink, Long Branch, Shark River, Trenton, Camden, Mt. Holly, Woodbury, Taunton and Atlantic City sheets have been published and are now on sale. The price is twenty-five cents per sheet, *payable in advance.* Order by *name* any of the sheets above indicated as ready, of the State Geologist, Trenton, New Jrsey.

GEOLOGIC ATLAS OF NEW JERSEY.

The State Geological Survey, in co-operation with the U. S. Geological Survey, is engaged in the publication of a Geologic Atlas of New Jersey. It will be issued in several parts, each part containing a complete discussion of the geography and geology for the region covered. Each volume will comprise (1) pages of descriptive text, (2) a topographic map, (3) geologic maps showing the distribution and structure of the various rock formations, the occurrence of all mineral deposits of economic importance, and (4) in some cases pages of half-tone illustrations. The following folios are now ready:

THE PASSAIC FOLIO, which covers the region from Morristown to Jersey City, and from Perth Amboy and New Brunswick to Pompton and Westwood, comprising 945 square miles; scale, 2 miles to an inch. It includes 27 pages of text, a topographic map, 3 geologic maps and a page of illustrations. Price, 25 cents; postage, 15 cents; if sent by express, charges collect.

THE FRANKLIN FOLIO covers the territory from Branchville and Newton, on the west, to Stockholm on the east, and from Andover and Petersburg, on the south, to Libertyville on the north, or 235 square miles: scale, 1 inch to a mile. In addition to the regular text and maps it includes a special study and description of the famous zinc deposits at Franklin Furnace, and of the white crystalline limestones. Price, 25 cents; postage, 15 cents extra; if sent by express, charges collect.

THE PHILADELPHIA FOLIO covers parts of New Jersey and Pennsylvania adjacent to Philadelphia. It is a double folio (scale 1 inch per mile), having four topographic maps, four geologic maps, two maps showing, by means of cross sections, the geological structure and the relation of the various rock formations to each other below the surface, a page of illustrations and twenty-four pages of descriptive text. Price, 50 cents; postage, 15 cents extra; if sent by express, charges collect.

THE TRENTON FOLIO describes the region around Trenton as far as Stockton, Millstone, Hightstown, New Egypt, Mount Holly, Delanco and Newtown, Pa., an area of 911 square miles. It contains descriptive text and three maps (scale, 2 miles per inch). It is published in two forms, the folio size (21¼ by 18½ inches) and a pocket or octavo size (9¼ by 6 inches). In the latter the maps are on thin paper, are folded and in a pocket. This size is more convenient for field use than the folio size. Price, folio edition, 25 cents, postage 15 cents extra; pocket edition, 50 cents, postage 10 cents extra. If sent by express, charges collect.

Other folios will be prepared and issued from time to time until the entire State is covered.

Orders for these folios should be addressed to the State Geologist, Trenton, N. J., and *remittance must accompany the order.*

ANNUAL REPORTS.

REPORT OF PROFESSOR GEORGE H. COOK upon the Geological Survey of New Jersey and its progress during the year 1863. Trenton, 1864, 8vo., 13 pp. Out of print.

THE ANNUAL REPORT of Prof. Geo. H. Cook, State Geologist, to his Excellency Joel Parker, President of the Board of Managers of the Geological Survey of New Jersey, for the year 1864. Trenton, 1865, 8vo., 24 pp. Out of print.

ANNUAL REPORT of Prof. Geo. H. Cook, State Geologist, to his Excellency Joel Parker, President of the Board of Managers of the Geological Survey of New Jersey, for the year 1865. Trenton, 1866, 8vo., 12 pp. Out of print.

ANNUAL REPORT of Prof. Geo. H. Cook, State Geologist, on the Geological Survey of New Jersey, for the year 1866. Trenton, 1867, 8vo., 28 pp. Out of print.

REPORT OF THE STATE GEOLOGIST, Prof. Geo. H. Cook, for the year 1867. Trenton, 1868, 8vo., 28 pp. Out of print.

ANNUAL REPORT of the State Geologist of New Jersey for 1869. Trenton, 1870, 8vo., 57 pp., with maps. Out of print.

ANNUAL REPORT of the State Geologist of New Jersey for 1870. New Brunswick, 1871, 8vo., 75 pp., with maps. Out of print.

ANNUAL REPORT of the State Geologist of New Jersey for 1871. New Brunswick, 1872, 8vo., 46 pp., with maps. Out of print.

ANNUAL REPORT of the State Geologist of New Jersey for 1872. Trenton, 1872, 8vo., 44 pp., with map. Out of print.

ANNUAL REPORT of the State Geologist of New Jersey for 1873. Trenton, 1874, 8vo., 128 pp., with maps. Out of print.

ANNUAL REPORT of the State Geologist of New Jersey for 1874. Trenton, 1874, 8vo., 115 pp. Out of print.

ANNUAL REPORT of the State Geologist of New Jersey for 1875. Trenton, 1875, 8vo., 41 pp., with map. Out of print.

ANNUAL REPORT of the State Geologist of New Jersey for 1876. Trenton, 1876, 8vo., 56 pp., with maps. Out of print.

ANNUAL REPORT of the State Geologist of New Jersey for 1877. Trenton, 1877, 8vo., 55 pp. Out of print.

ANNUAL REPORT of the State Geologist of New Jersey for 1878. Trenton, 1878, 8vo., 131 pp., with map. Out of print.

ANNUAL REPORT of the State Geologist of New Jersey for 1879. Trenton, 1879, 8vo., 199 pp., with maps. Out of print.

ANNUAL REPORT of the State Geologist of New Jersey for 1880. Trenton, 1880, 8vo., 220 pp., with map. Out of print.

ANNUAL REPORT of the State Geologist of New Jersey for 1881. Trenton, 1881, 8vo., 87+107+xiv. pp., with maps. Out of print.

ANNUAL REPORT of the State Geologist of New Jersey for 1882. Camden, 1882, 8vo., 191 pp., with maps. Out of print.

ANNUAL REPORT of the State Geologist of New Jersey for 1883. Camden, 1883, 8vo., 188 pp. (Price, 50 cents.)

ANNUAL REPORT of the State Geologist of New Jersey for 1884. Trenton, 1884, 8vo., 168 pp., with maps. (Postage, 8 cents.)

ANNUAL REPORT of the State Geologist of New Jersey for 1885. Trenton, 1885, 8vo., 228 pp., with maps. (Postage, 9 cents.)

ANNUAL REPORT of the State Geologist of New Jersey for 1886. Trenton, 1887, 8vo., 254 pp., with maps. (Postage, 9 cents.)

ANNUAL REPORT of the State Geologist of New Jersey for 1887. Trenton, 1887, 8vo., 45 pp., with maps. (Postage, 5 cents.)

ANNUAL REPORT of the State Geologist of New Jersey for 1888. Camden, 1889, 8vo., 87 pp., with map. (Postage, 5 cents.)

ANNUAL REPORT of the State Geologist of New Jersey for 1889. Camden, 1889, 8vo., 112 pp. (Postage, 6 cents.)

ANNUAL REPORT of the State Geologist of New Jersey for 1890. Trenton, 1891, 8vo., 305 pp., with maps. (Postage, 10 cents.)

ANNUAL REPORT of the State Geologist of New Jersey for 1891. Trenton, 1892, 8vo., xii+270 pp., with maps. Out of print.

ANNUAL REPORT of the State Geologist of New Jersey for 1892. Trenton, 1893, 8vo., x+368 pp., with maps. (Price, $1.55.)

ANNUAL REPORT of the State Geologist of New Jersey for 1893. Trenton, 1894, 8vo., x+452 pp., with maps. (Postage, 18 cents.)

ANNUAL REPORT of the State Geologist of New Jersey for 1894. Trenton, 1895, 8vo., x+304 pp., with geological map. (Postage, 11 cents.)

ANNUAL REPORT of the State Geologist of New Jersey for 1895. Trenton, 1896, 8vo., xl+198 pp., with geological map. (Postage, 8 cents.)

ANNUAL REPORT of the State Geologist of New Jersey for 1896. Trenton, 1897, 8vo., xxviii+377 pp., with map of Hackensack meadows. (Postage, 15 cents.)

ANNUAL REPORT of the State Geologist of New Jersey for 1897. Trenton, 1898, 8vo., xl+368 pp. (Postage, 12 cents.)

ANNUAL REPORT of the State Geologist for 1898. Trenton, 1899, 8vo., xxxii+244 pp., with Appendix, 102 pp. (Postage, 14 cents.)

ANNUAL REPORT of the State Geologist for 1899 and REPORT ON FORESTS. Trenton, 1900, 2 vols., 8vo., Annual Report, xliii+192 pp. FORESTS, xvi+327 pp., with seven maps in a roll. (Postage, 8 and 22 cents.)

ANNUAL REPORT of the State Geologist for 1900. Trenton, 1901, 8vo., xl+231 pp. (Postage, 10 cents.)

ANNUAL REPORT of the State Geologist for 1901. Trenton, 1902, 8vo., xxviii+178 pp., with one map in pocket. (Postage, 10 cents.)

ANNUAL REPORT of the State Geologist for 1902. Trenton, 1903, 8vo., viii+155 pp. (Postage, 6 cents.)

ANNUAL REPORT of the State Geologist for 1903. Trenton, 1904, 8vo., xxxvi+132 pp., with two maps in pocket. (Price, 40 cents.)

ANNUAL REPORT of the State Geologist for 1904. Trenton, 1905, 8vo., x+317 pp. (Postage, 12 cents.)

ANNUAL REPORT of the State Geologist for 1905. Trenton, 1906, 8vo., x+338 pp., with three maps in a pocket. (Price, 55 cents.)

ANNUAL REPORT of the State Geologist for 1906. Trenton, 1907, 8vo., vii+192 pp. (Postage, 10 cents.)

ANNUAL REPORT of the State Geologist for 1907. Trenton, 1908, 8vo., ix+192 pp. (Postage, 12 cents.)

ANNUAL REPORT of the State Geologist for 1908. Trenton, 1909, 8vo., xi+159 pp. (Postage, 8 cents.)

ANNUAL REPORT of the State Geologist for 1909. Trenton, 1910, 8vo., vii+123 pp. (Postage, 6 cents.)

BULLETINS.

In 1910 the series of Annual Reports was replaced by a series of Bulletins, each being a separate report upon some subject. Up to date seven Bulletins have been issued.

BULLETIN 1.—Administrative Report of the State Geologist of New Jersey for 1910. Trenton, 1911, 43 pp. (Out of print.)

BULLETIN 2.—A report on the Approximate Cost of a Canal between Bay Head and the Shrewsbury River, by H. B. Kümmel. Trenton, 1911, 20 pp., 1 map.

BULLETIN 3.—The Flora of the Raritan Formation, by Edward W. Berry. Trenton, 1911, v+233 pp. and xxix plates.

BULLETIN 4.—A Description of Fossil Fish Remains of the Cretaceous, Eocene and Miocene Formations of New Jersey, by Henry W. Fowler. Trenton, 1911, 192 pp.

BULLETIN 5.—The Mineral Industry of New Jersey for 1910, by H. B. Kümmel and S. Percy Jones. Trenton, 1911, 24 pp. (Out of print.)

BULLETIN 6.—Administrative Report of the State Geologist for 1911, including a report on Shark River Inlet by C. C. Vermeule. Trenton, 1912, 82 pp. and iv plates.

BULLETIN 7.—The Mineral Industry of New Jersey for 1911, by Henry B. Kümmel. Trenton, 1912, 37 pp.

March 4th 1913.

INDEX.

T.

GEOLOGICAL SURVEY OF NEW JERSEY

HENRY B. KÜMMEL, STATE GEOLOGIST

BULLETIN 9

A Preliminary Report

OF THE

Archaeological Survey

OF THE

STATE OF NEW JERSEY

MADE BY THE

Department of Anthropology in the American Museum of Natural History

Clark Wissler, Ph.D., Curator

Under the Direction of the State Geological Survey

COMPILED BY

ALANSON SKINNER

AND

MAX SCHRABISCH

TRENTON, N. J.

MacCrellish & Quigley, State Printers, Opposite Post Office.

1913

CONTENTS.

ILLUSTRATIONS.

PREFACE.

In April, 1912, the Legislature by an item in the supplemental appropriation bill, authorized the commencement of Archæological investigations under the direction of the Board of Managers of the Geological Survey. The appropriation made was very small but through coöperation with the Department of Anthropology, American Museum of Natural History, it was possible to expend this amount to great advantage. Nearly one thousand sites, camps, burial grounds and rock shelters were located and are noted in the following pages. Considering the small amount of money available, the progress made is very gratifying. This was due largely to the willingness of many persons to furnish the Survey full information regarding sites known to them. To Messrs. Schrabisch, C. C. Abbott, Edmund Shimp and R. W. Emerson in particular, the Survey is indebted for many facts, the result of years of study by each in the valley of Passaic River, the vicinity of Trenton and the vicinity of Bridgeton respectively.

In addition to the lists of sites given in the report, Mr. Skinner has kindly prepared a preliminary chapter dealing with the types of Indian remains found in New Jersey. Non-technical readers will find in this resumé much information on this subject, while to those more skilled in the science, it may contain considerable of interest. It is, of course, to be understood that in his treatment of any questions about which there may be a difference of opinion among archæologists, the author is expressing his individual views.

HENRY B. KÜMMEL,
State Geologist.

Letter of Transmittal.

AMERICAN MUSEUM OF NATURAL HISTORY
77TH STREET AND CENTRAL PARK WEST
DEPARTMENT OF ANTHROPOLOGY

NEW YORK, October 19th, 1912.

Dr. Henry B. Kümmel, State Geologist, Geological Survey of New Jersey:

SIR—We have the honor to submit herewith a preliminary report covering the first season's work upon the archæological survey of New Jersey which we have undertaken in coöperation with the Geological Survey under your direction. As a beginning and for the development of a definite plan for future investigation, a tentative list of sites was compiled, the locations of which have been plotted on maps supplied by your department. Unless otherwise stated in the text of the report, these sites were visited by members of the survey staff and their general character noted in respect to superficial surface indications. Owing to the hearty coöperation of local students and collectors, who gave freely of their time and accumulated data, we were able to formulate what we consider a satisfactory working classification of these sites. From the data at hand it appears that the surface sites so far reported are rare except on restricted areas in the northern, central, and southern parts of the State. Since this corresponds with the distribution of the Lenâpé Indians during the early settlement period, we may conclude that practically all such surface archæological remains belong to the historic Indian and his immediate ancestors. We have not thought it necessary to take up the question as to the probability of a pre-Indian population in the Trenton Valley and elsewhere, since such distinguished men as Dr. C. C. Abbott, Professor F. W. Putnam, and Ernest Volk have given years of patient investigation to that

problem. Suffice it to say that our preliminary work brought to light no positive new traces of such a pre-Indian culture.

The members of our staff also examined such private archæological collections as were placed at their disposal and checked over the types of specimens and their known distribution. The statements in the report covering this part of the work are, of course, quite tentative as many localities were entirely unrepresented. It is hoped that the publication of this preliminary report will encourage observers throughout the State to send in further information as to the location of sites and the distribution of specimen types.

The field-work was chiefly under the immediate direction of Mr. Alanson Skinner, assisted by Mr. Leslie Spier and Mr. Max Schrabisch. The accompanying report was compiled and arranged by Mr. Skinner and the supplementary report by Mr. Schrabisch.

Respectfully yours,

CLARK WISSLER,

Curator.

CHAPTER I.

Types of Indian Remains Found in New Jersey.

By ALANSON SKINNER.

SCOPE OF REPORT.

The archæology of the State of New Jersey is particularly interesting in that certain regions, notably the Delaware Valley near Trenton, are, and for some time have been, battlegrounds for the exponents and opponents of the theory of the existence of man in North America during early times. The claim has been put forward by one group of students that three horizons of human occupation occur: first, and nearest the surface, in the dark earth discolored by decaying organic matter, are the indisputable remains of the historic Delaware Indians; second, in the yellow soil beneath, the remains of a man who used tools and weapons constructed of argillite alone, as opposed to the great variety of materials worked by the Indians; and last, in the river gravels, rough artifacts of a cruder race, paleolithic man.

It seems unnecessary to recount here the history of investigations in and abaut Trenton under the leadership of such men as Dr. C. C. Abbott, Professor F. W. Putnam, Ernest Volk, and others, since their chief concern has been with traces of the earliest man. The present survey has so far given its chief attention to surface sites, or those pertaining to the Indian period of occupation, to determine their distribution and also to seek evidences for or against their homogeneity, and has not attempted to enter into the vexed question of a glacial man.

CLASSES OF REMAINS.

The remains of the most recent aboriginal inhabitants of New Jersey, the Lenâpé or Delaware Indians, may easily be classified

in the following divisions: camp and village sites, shell heaps, cemeteries, rock shelters, quarries, caches, and trails. Of these, the most abundant are the camp and village sites.

Camp and Village Sites.—These are generally situated near fresh water, often on a sandy, well-drained bluff or knoll, on the north side of a stream or lake, where the southern exposure gives added warmth in the coldest weather. Such sites are distinguished by the presence of stones cracked by fire (the Indians often boiled their food by heating pebbles and dropping them into the water), flint chips and cores, the refuse of arrow making and potsherds and implements of various sorts.

In some cases the shells of oysters and other shellfish litter the ground, and sometimes a circle of burnt stones outlines an ancient fireplace, and marks the exact spot where a wigwam stood. These circles are not infrequently disturbed by the plough in cultivated land, but as a recompense the ploughshare often throws up deer bones, split to extract the marrow, and other traces of aboriginal occupation.

There are no certain criteria for telling a camp from a village site, except that the former are usually smaller, contain fewer relics, and the earth is less impregnated with the dark stain of charcoal and decayed garbage that marks many of the older, long-occupied settlements. Of course, on the shifting sand dunes, especially in the southern part of the State, the discoloration is less likely to appear. It is on village sites that the greatest number and variety of Indian remains are likely to be found.

Another feature of many sites is the presence of sunken fireplaces and refuse holes or pits, long since filled with the débris of camp life. These are bowl-shaped depressions, anywhere from two and a half to four or five feet deep, filled with black earth darkened by charcoal and decayed organic matter, and often containing oyster shells, the bones of fish and animals, implements, whole or broken, potsherds, and other abundant relics of their makers. It is in such pits particularly that bone implements, whole or fragmentary pottery vessels, clay pipes, and other utensils, are most likely to occur. Often, in the winter, when the ground was too hard for digging with their crude tools,

the Indians placed the bodies of their dead in these pits, and covered them with débris. At times, when in peril, perhaps, the Indians concealed their little valuables under the refuse, and never returned, so that to this day, unless discovered by some accident, these treasure stores remain to reward the archæologist.

Shell heaps.—Shell heaps frequently mark the garbage dump of some old Indian village. They often occur near the sites of former settlements, always near water, and sometimes by themselves, far out on the salt meadows. Those on the marshes present the shell mound in its most typical form, and mark the spot where the Indian procured and dried oysters and other bivalves to carry inland for consumption. Often these heaps are of great size, like the mound at Tuckerton, and frequently they contain nothing but shells from top to bottom. Relics are never so abundant in any shell heap as they are on a village site, and often a search of the fields nearby will prove more productive than digging in the mound.

The shell heaps on the mainland are often not heaps at all, in the true sense of the word, although they may have been several feet above the surface in Indian times. The washing of earth or the blowing of sand has covered them with many inches of concealing soil, and they may only be found through the chance burrowing of some animal which throws out the shells, or the passage of a ploughshare through their midst. These mainland heaps are most apt to be true kitchen middens, and in them may often be found many of the objects that occur on village sites, and, as in the firepits, objects that would otherwise decay are preserved by the protecting soil and shells. Beneath the shell heap are often found the skeletons of the Indians themselves, perhaps interred there for concealment from foes, or for some reason unknown to-day. Fire pits and refuse holes are also found under the shell layers.

The late Dr. Frank Hamilton Cushing of Washington discovered that an Indian village stood on piles over the meadow near the great heap at Tuckerton, and in the muck he found the ends of the posts that once supported the lodges. This condition, while rare, is not unique, for many years ago the remains of an

Indian pile village, on Naaman's Creek in Delaware, was discovered and explored for the Peabody Museum, Cambridge, Massachusetts.[1]

Not all New Jersey shell heaps are composed of the waste part of the oyster industry. In Cape May County there are piles of clam and other shells that have been broken into many small fragments, probably in the process of manufacturing wampum beads. A typical shell heap can be distinguished from a natural shell bank by the facts that valves are very rarely found together, but scattered about, whereas they would be in contact in a natural deposit; many are broken, and the shells in the artificial shell heaps are nearly all of the same size, few small ones being found; and articles of Indian manufacture, implements, potsherds, fire-cracked stones and flint chips are hidden among the shells. In the case of very old heaps it often happens that crude implements are found toward the bottom, increasingly better ones higher up, and articles of European manufacture, obtained in trade with the whites, scattered on and near the surface. In some cases, shell heaps have been found that were used and abandoned several times. During the periods of non-occupation, sand drifted over the surface, so that excavation reveals several layers of occupation; such strata are to be expected in New Jersey shell mounds, though none have as yet been reported.

Cemeteries.—The typical Indian cemetery in New Jersey is practically impossible to locate except by accident, as there are rarely if ever any surface indications to point out the spot. The place of occurrence of such a cemetery is also uncertain. Often one may be found on a high sandy knoll opposite the village. Again the burial ground may be in an adjoining lowland field under a shell heap, or the bodies may be found in and among the hearths in the heart of the village itself.

The typical graveyard is, however, on a warm, sandy hillock near the village. The skeletons are usually found lying on one

[1] Pile structure in Naaman's Creek, near Claymont, Delaware, Archæological and Ethnological papers of the Peabody Museum of American Archæology and Ethnology, Vol. 1, No. 4.

side, drawn up "in a sitting posture", the knees before the face. In the majority of cases no objects are found in the graves, and only the black soil near the bones betrays their presence. However, in some places, notably at Chestnut Neck near New Gretna, at Morgan's Station, at Tottenville, Staten Island (politically in New York, geographically in New Jersey and occupied by New Jersey Indians), many objects have been found in the graves. The most common of these were flat-based, highly polished monitor pipes of steatite, and stone pendants or gorgets, but it does not seem to have been a custom of the Lenni Lenâpé or Delaware Indians to bury pottery vessels with their dead, as did their fierce neighbors, the New York Iroquois. In addition to this variation from the usual Lenâpé custom of putting nothing in the grave, we find other curious features. Sometimes the bodies are laid at length in the grave, as we bury, but this is unusual. Often a mere mass of disarticulated bones, bundled together, with the skull on top, is found. This is doubtless due to the custom, sometimes described by the old writers, of bringing home the bones of those who died at a distance to inter them in their native land. The bare skeletons when exhumed often look abnormally large to the inexperienced amateur archæologist, and hence have given rise to weird tales of a gigantic race.

Artificial burial mounds do not exist in New Jersey. They are frequently reported, but investigation has invariably shown that the Indians have made use of a natural elevation for their interments. No earthworks or mounds of aboriginal manufacture are known in the State, popular tradition to the contrary notwithstanding.

Rock Shelters.—In the northern part of the State, in the mountains, the aborigines took advantage of the shelter offered by nature, and under overhanging cliffs, in caves, and even about the concave sides of huge detached boulders, where there is a southern exposure, or more important still, near fresh water, traces of their occupation may be found. In the cave dirt that litters the floors of these retreats, many objects of Indian make may be exhumed. Mr. Max Schrabisch, of Paterson, who has explored and excavated more of these than any other person,

has made the interesting discovery that the earliest occupants had crude tools and no pottery, a fact that has been corroborated by the rock shelter work of Mr. M. R. Harrington in Westchester County,[1] New York, and Mr. Elmer T. Gregor, in Pike County, Pennsylvania. This, to a certain extent, connects the earlier "cave dwellers" with the nonpottery-making argillite users of the Delaware Valley. Needless to say, the rock shelter is a feature of northern New Jersey, physiographical conditions precluding their presence in the southern part of the State. The rock shelters yield nearly all the forms of implements found on the village sites, and generally they are easier to find, since they are crowded into smaller compass. An interesting feature, common to many rock shelters, is the presence of a dump near at hand where the sweepings of the retreat have accumulated, and where the best relics of its occupants may be found. The importance of the rock shelter as a repository for records of aboriginal occupation, curiously enough, has been slighted, and it has remained for Mr. Schrabisch to make an exhaustive study of those occurring in this State.

Caches.—Here and there, but more particularly in the vicinity of Trenton, hoards, or as they are often called, caches, of implements are found. Flint, when newly quarried, still retains moisture known as "quarry water", and when damp is far easier to work than later, when it becomes dry and brittle. It is assumed that the Indian knew this, and after having blanked out a number of leaf-shaped forms that could be used as they were, and needed only a few finishing touches to specialize them as knives, spears, drills and what not, he buried them in the earth where they might retain their moisture and await his leisure. But not all caches consist of these leaf-shaped blades, for hoards of grooved axes, celts, copper implements, and other things have been found, and for these the explanation fails. Some may have been surplus stock of traders, others, perhaps, were hidden to prevent them from falling into the hands of the enemy,

[1] See M. R. Harrington, "The Rock Shelters of Armonk, New York" (Anthropological Papers of the American Museum of Natural History, Vol. 3, pp. 125–138).

still others were possibly sacrifices to the Powers Below. Who can tell, except the spirit of him who so carefully deposited them for us to find?

Quarries.—In some localities, where there are argillite or quartzite outcrops near the surface, native quarries have been found. Blocks of material lie detached, and with them the chips, cores, rejects, and failures of the process of arrow making. Stone mauls and hammers nearby also tell of the quarryman's industry, but usually there are no perfect examples of the tools at which he toiled, for he took them away as the fruits of his labor. Sometimes, too, he carried off the rough flint, and finished the work at his lodge, or even paused besides some spring at noonday, and there continued his task, for often, on a village site, or far away in the woods, one may find a little pile of chips that remain to show where some solitary workman shaped his points. Often, too, the traces show that he used a chance drift pebble of jasper or quartz for his material and not a chunk of flint wrenched from the quarry.

Trails.—In many different parts of the State, traces of Indian trails still remain. On Dr. C. C. Abbott's farm near Trenton, there still exists part of the old footpath from Chester, Pennsylvania, to Manhattan. It fords the Delaware at Bristol, crossing to Burlington, and passing up the river, crosses Crosswick Creek where the Bordentown trolley bridge stands, goes on to the Assanpink, follows its valley upwards towards its headwaters, parallels the waters of the Millstone along its bank, fords the Raritan, and circles about to Manhattan. Where preserved on the Abbott farm it is worn deep by the passage of countless soft-shod feet, and is green with moss. So fresh and well defined is it, that, standing under the shade of the primeval beeches, one expects at any moment to see a half-clad troop of Lenâpé, loaded with packs of furs, step noiselessly along its course. Again along the east shore, on the mainland behind the bays, there can still be seen in detached fragments, part of the old north and south path of the Indians. In some places, notably in the dense cedar swamps north of Toms River, log causeways are reported, that still serve to keep dry the feet of roving hunters.

These causeways seem surely to have been the work of the Delaware Indians. In other places one may yet see the remains of the stepping stones that the Indians piled in the river in order that they might cross dry shod. These are easily confused with the zigzag stone walls that here and there cross our rivers, marking the old fish weirs of the savages.

DISTRIBUTION OF THE INDIAN.

A persistent tradition among the descendants of the old settlers of New Jersey states that the Indians lived most of the year in the valley of the Delaware, and came to the coast only at certain seasons to hunt and fish. The results of our survey, while only preliminary, tend to confirm this. Along the shores of the great bays of east New Jersey from Navesink to Cape May there are few traces of permanent settlements. The shell heaps and camp sites that abound betoken frequent use of the same spot during the fishing season, but not continuous occupation. Village sites and burial grounds are few and far between, Tuckerton and Beesleys Point being notable exceptions. The great mass of villages and cemeteries, with their countless variety of relics, are along Delaware River and its tributaries. In the sandy interior of the southern part of the State there are comparatively few traces; it was a hunting preserve. In the northern part, there are more, and there seem to have been extensive settlements about New York and Raritan Bays, especially on Staten Island. The lands adjacent to Newark Bay and the valleys of the Passaic and Hackensack are also filled with Indian traces; the ledges of the mountains furnish rock and cave shelters, and there were extensive settlements on the upper Delaware.

In a way, the evidence goes to corroborate our historical knowledge. We are aware that the Lenâpé were divided into three parts; in the northern part of the State, the Munsee; in the central, the Unami; and in the southern, the Unalachtigo.[1]

[1] A brief but highly instructive summary of the historical facts supporting the view that the Lenâpé found no other people in New Jersey when they migrated thither was made by Dr. Ales Hrdlicka in a discussion of Trenton Crania. (Bulletin, American Museum of Natural History, Vol. 16, pp. 32–41.)

Our survey so far shows clusters of sites, extensive and long occupied, near Bridgeton on Cohansey Creek, doubtless the headquarters of the Unalachtigo; at Trenton, and on Staten Island and vicinity, are the main Unami settlements; near Belvidere and Columbia the fields are rich with traces of the Munsee.

In the year 1836, Constantine Samuel Rafinesque published in Philadelphia a work entitled, "The American Nations, or, Outlines of a National History of the Ancient and Modern Nations of North and South America."[1] In this collection is included a translation of the "Walam Olum" or "Red Score" of the Delaware, the cosmogony and migration myth of the tribe. For many years the authenticity of the document was doubted, but Brinton and other scholars have proved its genuineness, the final and best translation being made by Dr. Brinton with the assistance of the Rev. Albert Anthony, an educated Lenâpé Indian.[2]

After a description of the creation of the world, the Walam Olum relates that the Lenâpé were living in a cold land to the north, sometimes identified as Labrador. The climatic conditions were so severe that they were forced to leave, and journeying southwest they came to a stream which seems to have been the St. Lawrence, which they crossed on the ice. They tarried for a time in the middle west, and then journeyed east again, warring with the Talega, who seem to have been the Cherokee, who built mounds and fortifications. Having subdued the Cherokee and driven them away with the aid of an Iroquoian tribe, supposed to be the Huron or their kindred, they soon tired of their new territory and pushed eastward until they struck the sea coast. Here they settled, spreading out and splitting up into various divisions, a happy and prosperous people until the white man came. The rest of their story is one of misery and exile, and it can be found in any history of the region.

PREDECESSORS OF THE DELAWARE INDIANS.

The Lenni Lenâpé, although found here by the first white settlers, were not the oldest inhabitants of the region. Beneath the

[1] See D. G. Brinton, "The Lenâpé and Their Legends," p. 151.
[2] Vide, ibid, p. 156.

immediate surface, darkened by the refuse from Indian habitations, chipped implements of argillite have been found in the undisturbed yellow soil under conditions that suggest considerable historical antiquity. No pottery or implements other than large rough argillite points, blades and the like occur, whereas the Lenâpé layer above is rife with pottery, implements of all kinds, and materials. In the valley of the Delaware this phenomenon has been amply observed and investigated by Dr. C. C. Abbott, Mr. Ernest Volk, and others.[1] Mr. Lockwood is said to have noted it at Keyport, in the shell heaps, and Messrs. Edmund Shimp and R. W. Emerson of Bridgeton have recorded the presence of at least one site on Cohansey Creek, where crude argillite tools alone occur. Mr. Schrabisch in his work on New Jersey rock shelters, Mr. Gregor in Pennsylvania, and Mr. Harrington in New York report the presence of a nonpottery-using people as shown by the bottom, hence the oldest, layers in the débris of the caves.

There has been much controversy about the question, but when the same conditions are found by independent observers in different localities, where these finds and reports are unanimous and consistent, one cannot but admit the truth. The rub comes on the relative age of the finds, and here we find the archæologist and the geologist are at odds. The former often claims great geological antiquity for his finds, the latter denies it. Assuming that each is thoroughly competent in his own science, the writer is forced to take the middle ground, and while convinced of the existence and authenticity of the argillite finds he is obliged to consider them as of great historical age only, and perhaps relatively recent from a geological standpoint. Possibly there was an argillite culture here before the Delaware or Lenâpé Indian that our ancestors knew, but to say that these people were of a different race, a race that could be called pre-Indian, is too much, though they may be called pre-Delaware with some certainty. The Walam Olum also makes it appear that the Dela-

[1] See especially "The Archæology of the Delaware Valley," by Ernest Volk (Papers of the Peabody Museum of American Archæology and Ethnology, Harvard niversity, Vol. 5); also "Archæologia Nova Cæsarea," "Ten Years' Diggings in Lenâpé Land," and other works by C. C. Abbott.

ware came into New Jersey with a well-developed culture and clinches the case. The Lenâpé of course used argillite implements, often not to be distinguished from those of their predecessors, but they are found commingled with jasper, flint, and quartz, not isolated, and generally in a different cultural horizon.

As for the still older "paleoliths," that such exist in the Delaware Valley seems to be demonstrated by Volk, although some archæologists are not satisfied that the remains are of human origin.

UNSETTLED PROBLEMS.

Lenni Lenape.—We have seen that the problems which present themselves to the student of the archæology of New Jersey are threefold, according to the phases of the work in hand, but there are other minor problems within these that cry for an answer before we can properly take up the greater ones. In the case of the historic Lenâpé Indian we should like to know where he came from, at what place or places he first entered our borders, how and in what manner he developed and advanced in culture, after arriving, if indeed he did, and lastly, his relations with the peoples west, north, and south. The study of historical and documentary evidence, such as the Walam Olum, bearing on the Lenni Lenâpé, and the investigation of the ethnology and folklore of the tribe as represented by the surviving remnants in Canada and Oklahoma will help on the first problem, aided by archæological work along the lines indicated by the results of this survey, to see whether the migration can be traced to its source.

It is not improbable that the Lenâpé, as scattered bands, may have struck the boundaries of "the country by the Great Water where Daylight Appears" in several places. On the other hand, according to the evidence so far brought out by our survey, it seems possible that some of the oldest and most extensive settlements of the Lenâpé were on Cohansey Creek near Bridgeton, and therefore that locality may have been one of the first abiding places of the Lenâpé in this State, and the one from which they spread. It is not good to jump at conclusions, however, and we must await further evidence before definitely stating this to be

the case, since there are several other localities which deserve attention, especially some of those in the neighborhood of Paterson investigated by Mr. Schrabisch, which seem to mark very old sites.

In the Paterson region the sites, exclusive of the rock shelters are unusually rich in all the commoner implements, but are poor in pottery, and lack almost wholly the finer articles, especially ornaments of polished stone. This may show, when Mr. Schrabisch's work is completed, and correlated with the results of other workers, that the earliest Lenâpé, or their predecessors, were not so far advanced as the inhabitants of Trenton and the vicinity of Staten Island, where the finest examples of stone work and pottery have been found.

For a definite knowledge of the cultural position of the Lenni Lenâpé as shown by their archæology in comparison with that of their neighbors, we need more detailed information from South Jersey, and from the Delaware Water Gap region. So far as can now be judged, the Lenâpé at their best had reached a higher point culturally than the New England tribes, the New York Coastal Algonkin, or the tribes to the south at least as far as the Powhatan region. They had developed a beautiful and characteristic pottery, excelled in work in stone, and had evolved several types of stone articles that are unique.

The pre-Lenapian argillite users.—The matter of the argillite using pre-Lenâpians of the Trenton region is very interesting. We have seen that argillite finds are reported at least from Bridgeton and Keyport, and it is of importance to know where else their remains are or are not found. It is highly probable that the culture of these people connects itself with that of the nonpottery-making aborigines whose remains occur in the lowest layers of the New York, New Jersey, and Pennsylvania rock shelters. It behooves us to see what can be found in the bottom strata of the great shell heaps along the coast. It is the belief of the writer that the argillite culture represents an eastern migration of Algonkin peoples older than the advent of the Lenâpé, although it would not be altogether surprising if they proved to be the earliest wave of the Lenâpé themselves. So much has been written and said about the so-called paleolithic

remains that their problems need not be discussed here. Further data from other sources than Trenton are much to be desired.

TYPES OF SPECIMENS.

The objects remaining to us of Lenâpé industry may be arbitrarily classed by their material into articles of stone, clay, copper, bone and shell. Since the first of these are the most abundant, the Indian may be regarded as living in the "stone age," at the advent of the white man. This does not mean, however, that he used only implements of stone.

As a matter of fact, wood, clay, bone, antler, fabrics and a dozen other things were used by the savage simultaneously with stone, the latter indeed, only furnished him with such tools for which we employ metal to-day. Our New Jersey Indians, who had reached an advanced stage in the knowledge of the processes of working stone, had many other things besides their implements of this material. Wooden bowls, carved from knots, wooden mortars, pestles, spoons, canoes, masks, bows, and a dozen other things were in everyday use. Bags, garments and nets woven of string made of native hemp or the inner bark of trees; bags, clothes, and utensils of skin; awls, arrow points, knives, cups and scrapers of bone and antler, mats, and basketry of reeds, flags, bark, grass and corn husks, and so on, a thousand and one things, not now preserved in New Jersey, for the most part, but described in the writings of the early travelers were in daily use. A few very old pieces, said to have come from this locality, are still in the hands of the exiled Delaware in Canada and Oklahoma. We cannot truly say that the Indian was living in an age of stone alone, any more than we can call him inartistic because his beautiful aboriginal art products, such as the woven turkey-feather robes and dainty porcupine-quill embroidery have vanished. Thus it is, that in the shell pits and heaps, graves, and old wigwam sites of our Indians we find a number of implements of bone, turtle shell, and antler, the existence of which might never be suspected if we confined our search to the surface.

In the presence of Dr. Abbott's well-known works on the "Stone Age in New Jersey," "Primitive Industry," "Archæologia Nova Cæsarea," and "Ten Years' Diggings in Lenâpé Land," it is useless for the writer to describe and classify each type in detail. It is sufficient for present purposes to discuss only the typical objects of each class.

Articles of Stone.

Stone articles may be subdivided as follows:

a. Implements of rough or pecked stone.

b. Implements of polished stone.

c. Implements of chipped stone.

We further find that the first order may be divided into two parts:

1. Articles of natural stone, shaped by usage and only slightly worked.

2. Objects deliberately fashioned by the exertion of labor and skill.

Rough Stone Implements.—In the first class, we have in order of abundance: first, hammer stones, plain pebbles for various homely uses, generally, but not always, battered upon the ends and sides, and often with a pit pecked in each side to facilitate the grip with the thumb and forefinger, especially when the tool has become greasy, a not unknown occurrence in the case of Indian property. Around Plainfield a number of hammer pebbles with two pits on each side have been collected. Sometimes pebbles were grooved about the lateral axes to serve as mauls or hammers.

Besides these hammer stones there are larger pitted stones, often with a deep abraded hollow on one side only, as though the pebble had been used as an anvil or a lapstone. Then there are stones which have been incidentally shaped while used for grinding and polishing, a process which often wears away the original rind, and thus determines the nature of the tool for the archæologist. Net sinkers are field pebbles, notched on two or more sides to receive a cord, or, more rarely, grooved about the long or short axes for the same purpose. A form found, to

my knowledge, only in New Jersey and Delaware, is a flat pebble with a hole near the edge carefully pecked in from both sides. These perforated stones were probably weights or sinkers. For the milling of their corn, mortars made of boulders were used. These are cupped on the upper surface to receive the grain when the rock is heavy and bulky, but when a slab or a small stone was used, there are often hollows on both upper and under surfaces, and examples are known in which these hollows have been worn through, and the stone rendered useless because of the resulting perforation. This is also true of some of the smaller anvil stones which are double-faced. The long cylindrical pestle, made by carefully pecking at and dressing down a suitably shaped pebble, and therefore falling into our second subdivision, while not uncommon, was not, as many think, used in connection with the shallow stone mortar. It functioned with a wooden mill made from a section of a tree, with a receiving cup for the corn burned and scraped in one end. A round pebble, a grinding stone or muller, was used with the stone mortar. Such specimens have up to very recently, been collected among the New York Iroquois, and there is ample historic evidence concerning the connection of the long stone pestle and wooden mortar. The writer and others have obtained such utensils from living Indians. The round grinding stones or mullers used with the stone mortar show their purpose by the fact that the surface is rubbed away where the tool came in contact with the metate or slab.

Arrow-shaft smoothers are blocks of gritty stone with deep grooves wide enough to receive the arrow and through which the wooden shaft was rubbed to shape it. Related to these are the smooth pebbles with grooves worn in the edges through which thongs or sinews have been run back and forth to dress them. These are sometimes perforated at one end for suspension.

Crude chipped blades are found that may have been used as lances or spades. They are lanceolate in shape as a rule and often the edge is polished as if by contact with the soil. They are crude indeed in comparison with the chipped flint hoes of the Middle West.

Besides these articles of rough stone, we have those that have been pecked carefully into shape by a stone hammer, and often polished highly by way of finishing. These include grooved axes, wedge-shaped implements with a groove entirely encircling the broad base, or with one side flat. Some have two grooves, but none with double blades have been reported. These axes vary in size and weight from toys an inch or so long to clumsy tools weighing fourteen pounds. Some are very highly polished, others only show the pecking. These were probably hafted by splitting one end of a stick, setting in the blade, making the handle fast in the groove, and lashing the split together above and below the stone. When the blade of such an axe was broken it was often used as a maul.

Celts are stone hatchets without the groove, are usually smaller in size, and have a tapering butt. A number of usages are assigned to these implements, but several have been recovered with the original handle still preserved, showing that they were most commonly used as axes. In the American Museum of Natural History of New York, there is one which was dredged from the muck at the bottom of a pond in Thorndale, Dutchess County, New York. Partial charring aided the mud in perserving the wood. The handle was club-shaped, tapering to the grip, and the blade was set in a hole which was pierced through one end, the butt protruding above the top. Smaller chisel-like celts were set in the handle, not through it. Stone gouges, shaped very like our metal tools, and adzes like the grooved ax, with one side flat, are reported.

Pestles were long stone cylinders carefully pecked from river pebbles, and used as described above with hollow wooden mortars. Stone mortars are often found in the shape of boulders cupped on one or both sides.

Polished stone.—The more beautifully finished and polished stone utensils of the Delaware were not many in number. Pendants, flat and perforated at one end for suspension, double-holed pendants, or oblong "gorgets," with a hole near each end, have been collected in New Jersey in considerable numbers. Surviving Lenâpé claim that they were used as hair ornaments.

A very splendid class of relics, for which we have not data as to use, are the banner stones, beautiful butterfly and pick-ax shaped objects, polished and perforated, and grooved or notched in the middle. They have usually been considered as ceremonials and it is impossible to say anything more definite of them.

Around Imlaystown and Cream Ridge several small polished stone objects, resembling "husking pegs" and so called by local collectors, have been found; they seem not to occur elsewhere.

Stone pipes are uncommon indeed. They are usually of the flat-based monitor type, but a few catlinite pipes are reported. These, of course, have been imported from the west. Stone tubes, perhaps uses as pipes, possibly used by medicine men to suck disease from sick persons, as bone tubes are used to-day by Indians in the west, are rare, but occasionally found.

The remarkable stone heads, characteristic of the region, are commented on more fully elsewhere. This is but a brief list of the more common archæological forms in stone.

Chipped Stone.—Everyone is familiar with the countless thousands of arrow points, knives, "spears," drills, scrapers, and other chipped stone implements found scattered all over the State.

These were made by several processes, the most common one in the east being as follows: The flint, jasper, quartz, or argillite was quarried from the bed rock, or drift pebbles were broken up into rough blocks with a stone maul. The blocks were further dressed roughly into shape by means of a stone hammer, probably just an ordinary pitted pebble, and the finishing touches were made by flaking with a piece of bone or antler. The last tool was of about the size and shape of a lead pencil, and was manipulated by placing one end against the edge of the flint and pressing firmly. The pressure caused long delicate flakes or chips to fly off, and so the work was done.

Pottery.

The typical pottery vessel of the Delaware Indians was shaped "like an egg with the top cut off". That is, it was somewhat conical in shape, and possessed a pointed bottom. In the north-

ern part of their range, where they came into contact with the Iroquois, the Lenâpé adopted or adapted several of their pottery forms. The typical Iroquois vessel had a round bottom, a constricted neck, and a heavy, often square-cornered collar or rim, which was commonly ornamented by incised lines, and the angle between the neck and collar was frequently notched. Several intermediate types occur.[1]

In making their pottery the Lenâpé sought good, stiff, tenacious clay which they dug and pounded, mixing with it burned shells or pebbles to temper the material and cause it to hold together more firmly. When the clay was properly prepared it was made into long rolls by the potter, and these rolls were coiled upward, the one upon the other, from a small point which formed the bottom. When the vessel was shaped, it was smoothed over, while the clay was still damp, by means of a slick pebble, and the ornamentation was cut, scratched, or stamped near the rim. Often a paddle wrapped in cloth was patted over the soft sides, leaving the impressions which we call fabric marks. When the vessel was finished it was fired, and was a durable and light receptacle for liquids.

If, by some misfortune, such a vessel was dropped and cracked it was often mended by making a series of perforations along both sides of the crack and lashing or lacing it tightly together by means of a thong or string. It was then still useful for storing corn or dry stuffs of any sort, though too leaky for water.

Fragments of pottery showing the shell and pebble tempering, or broken in such a manner that the edges of the coils that formed the foundation are visible, are often found, and other pieces, still bearing witness to the manner in which the pot was laced together after cracking, the proof being found in the perforations themselves, are frequently picked up.

In size, the pottery vessels of the Lenâpé ranged from large vessels holding four of five gallons to those that are only capable

---

[1] See Skinner, "Archæology of the New York Coastal Algonkin," pp. 222–227. (Anthropological Papers of the American Museum of Natural History, Vol. 3.)

of containing a pint or so. A few vessels are found showing that a sizing or wash of fine clay was spread over the pot to enhance its appearance. More rarely traces of red ochre show that the entire kettle was daubed with paint. Designs painted on the vessel seem never to have been employed, and nearly all the figures in the stamped or incised work are geometric and angular. Curvilinear figures are very rare, and life forms almost unknown. An exception is part of a large vessel of old Algonkian design, with a pointed bottom, found by the writer in a shell pit on a village site at Bowman's Brook, Mariner's Harbor, Staten Island, New York; on the sherds that represented fragments of the rim were several crude human faces modeled in relief. Other crude outlines of the human face have been found on potsherds from Manhattan Island. In each of these cases the specimens were on pottery of the Iroquoian type, although those found by the writer, while on an old Lenâpian vessel were associated with Iroquoian potsherds. Representations of the human face and even the whole body are not infrequent on Iroquois vessels and pipes.

Clay pipes were extensively used by the Lenâpé. They were never so elaborate nor decorated with life forms as were those of the Iroquois, but were smaller and ornamented with very delicate distinctive designs quite similar to those on the kettles. Some were straight tubes, often scarcely expanding to form the bowl. Others had a small bowl turned up at right angles, to the stem, and others again were trumpet-shaped. A few of the latter had a swollen bowl with a flaring rim, resembling a flower to a certain extent. Eccentrically shaped pipes, with thin, flat, broad stems, and large, cylindrical swollen bowls, are found. In these the bowl usually juts off from the stem at an angle of 45 degrees. In nearly all cases the bowl is the only part of the pipe that is ornamented. A few pipes have a swollen mouthpiece, evidently to facilitate grasping it between the teeth.

Very few objects of clay other than the pipes and vessels above described are found in New Jersey. A notable exception is a splendid pottery head, collected by Dr. Abbott from the vicinity of Burlington on Rancocas Creek. This most excellent example

of Lenâpé art is figured and described at length in his "Ten Years' Diggings in Lenâpé Land", p. 29. Dr. Abbott quotes a friend who is inclined to think it modeled by an Indian artist who drew his idea from a meeting with an oriental or an Eskimo. I cannot agree with him, and believe that the Asiatic appearance of the face is more fancied than real, and is due to the limitations of the maker's skill and material.

Bone Implements.

Articles made of bone and antler are much more common in New Jersey than is generally supposed, owing to the fact that the average local collector draws most of his material from surface finds in ploughed fields, and seldom resorts to excavation. Of course, only the most imperishable objects of the Indians' hoard, the stone and clay utensils and weapons, are preserved under such conditions, and for the bone and antler specimens it is necessary to seek in the preserving soil.

Awls are usually made of slivers of bone merely ground to a sharp point at one end. Often, however, they are large and elegantly finished, and, when found under favorable circumstances, show a high polish acquired by use. They were doubtless used to sew buckskin, just as our shoemakers use metallic awls to-day, but, as they are frequently found along with oyster shells, split and charred bones, and all the débris of a feast, it may be that they sometimes saw service as forks for pulling scalding morsels from the kettle. One awl was collected from a shell pit in a field near Fairton, Cumberland County, which was notched at the base, perhaps for suspension.

Bone needles are sometimes found. These were usually manufactured from the thin, flat, curving ribs of some animal, dully pointed, at one end, only, and with a perforation or "eye" in the middle. The Algonkin Indians living in the middle west still use a very similar needle for sewing bullrushes together to make the mats with which they cover their wigwams.

Besides these needles, scrapers, made from the leg bones of deer, split lengthwise and used like a primitive draw shave to

remove the hair from deer skins during the tanning process, are not uncommon. We have not yet heard of any bone fishhooks from New Jersey.

Arrow points were made from bits of bone fashioned into long, triangular shape, or from the pointed, sharp-edged fish plates of bone. No doubt the Delaware also used the tip of the tail of the horseshoe or "king" crab, and the claws of birds and animals for arrow-heads, but none have been reported. Cups made of shell of the box tortoise are found, but, although we have records of hoes with bone blades, no doubt the scapulæ of large mammals, none have been reported within our area. In a grave at Tottenville, on Staten Island, New York, an implement of bone resembling a hoe or scraper, has been found. We know of but one of the hollow, cylindrical, tubular bone beads so abundant in western New York, and harpoons of bone have not been reported.

In antler we have a pin with a round head from Staten Island; cylinders, probably used in flaking out arrow points by pressure (see p. 25), and tines hollowed and sharpened for use as conical arrow points. This seems to be all that we have in the way of bone and antler utensils, a meager showing as compared with the finds in western New York.

Articles of Shell.

Shell articles are very rare in New Jersey. We might expect to find wampum beads, since they were extensively manufactured by our Indians, yet few, if any, have ever come to light. This is true of all New England and the Middle Atlantic Coastal region. No doubt all the wampum (cylindrical beads of blue or white shell, a quarter of an inch in length and about an eighth of an inch thick) was traded inland. Some shell beads of recent type, representing animals, fish, etc., have been found in an historic Indian cemetery at Trenton.

Metallic Articles.

Metal implements are exceedingly scarce throughout the State. Four native copper articles, two of which are now in the Pea-

body Museum at Cambridge, are reported by Dr. Abbott from Trenton. These are three spears or knives and a celt. They were perhaps made from copper mined within our boundaries, or, possibly from one of the drift boulders of this material that sometimes occur.

All the old deeds signed by Indians contain a multitude of references to metallic articles received in exchange for their land. We know that tomahawks, hoes, axes, adzes, awls, fish-hooks, guns, knives, beads, wampum, and a thousand other things were given the Indians by the whites, yet how rarely do we find an iron trade ax, a brass arrow point, or a glass bead. On Burlington Island, it is true, Dr. Abbott excavated the site of an old trading post, and there found many things of this nature, but on the sites of the Indian villages these things are rare indeed. I cannot explain it. All trade articles used by the Iroquois are found in great profusion on all the sites of their historic towns in western New York.

LENAPE IMPLEMENTS COMPARED TO OTHER TYPES.

The material culture of the Lenâpé Indians, as shown by their archæology, presents a number of strong contrasts with that of their neighbors, and possesses an individuality which in many instances sets it off as distinctive. Although the Lenâpé may have been, when they first entered the country, "skilled in many crafts, yet not preëminent in any," as Dr. Abbott says, it is certain that their remains, as we know them, show that they were indeed past masters in the art of shaping stone by every primitive process. The abundance, variety, and workmanship of Lenâpian stone implements by far exceeds that of the Iroquois.

The grooved stone ax in many varieties, the long stone pestle the delicately fashioned and handsomely polished monitor pipe, the banner stone, the double-holed gorget, and the remarkably made stone heads of the Delaware country were rare or unknown

to the Iroquois,[1] as were the innumerable forms, often highly artistic, of chipped-stone weapons and tools.

The stone pipes of the Iroquois, at their best, probably surpass most articles of Lenâpé manufacture, but, taken all in all, the Delaware as much exceed the Iroquois in stone work as they fall behind them in the potter's art. The clay vessels of the Lenâpé were good. In form they resemble, as a rule, the typical, nearly conical vessels of the Coastal Algonkin. In decoration they are distinctive, for the Lenâpé employed many not inartistic incised combinations, particularly of the "chevron" and "herring bone types", which we have not seen duplicated outside their territory, and which may have been influenced by the art of their neighbors further to the south. On the other hand, the remarkably graceful outlines of the Iroquois vessels are wanting. So far as shape is concerned, the typical Lenâpé jars are monotonous, except in specimens from later sites, situated in the northern part of the area, where Iroquois influence had crept in, and where Iroquois styles had been adopted in whole or part. In like manner the simple trumpet, angular, and tubular clay pipes of the Lenâpé cannot be compared in abundance, number of forms, or finish, to those of the Iroquois, but their decoration consists of delicate incised tracery found in no other region.

In bone, antler, and shell, the story is the same. Just as the Lenâpé surpass their Algonkin neighbors in New England in regard to the abundance and elegance of these products, they fall equally short of their Iroquoian foes. The bone awl, arrow point, cylinder, tortoise shell cup, and a few other implements make a good showing perhaps as against the relatively fewer remains of this nature from New England, but sink to insignificance before the splendid array of Iroquois artifacts, bone and antler combs, harpoons, dolls, gorgets, wedges, fish-hooks, awls, needles, cylinders, tubes, spoons, and what not. Then too, the tremendous abundance of shell articles, especially

[1] While objects of this nature are occasionally found on the surface in the Iroquois country, we have no record of the finding of any of them during the systematic excavation of the older true Iroquoian sites by trained archæologists. On later sites which mark the villages where Algonkin or other captives were kept and adopted en masse, we may, however, expect to find them.

on later Iroquois sites, has no Lenâpian analogy. The New England area has a greater relative number of pendants, gouges, adzes, semilunar knives, and perhaps, long stone pestles, but all these things are found, though sparingly, or even rarely in some instances, in Lenâpé territory, along with the multitude of common types. On the whole, it may be said that the Lenâpé had few original forms in stone, but that they perfected the art of making the types they knew to a degree beyond most of their neighbors.

Nevertheless, it is only fair to say that the Delaware did have some types that are unique. Take for example the large stone heads, a number of which have been found in various places in New Jersey, on Staten Island, and in Lenâpé territory, or the territory of their near ethnic and linguistic relatives on the Upper Hudson. These heads were no doubt the outgrowth of certain religious concepts, common to the Delaware and their closest relations, which are recorded by Brainard and other early authors and are still in vogue among the surviving Lenâpé in Canada and Oklahoma,[1] where examples, representing the faces of mythological characters carved in wood are still to be found. Some of these ideas are, indeed, similar to those of the Iroquois, yet Iroquois religion and mythology seems to have found no corresponding outlet of art in stone of this precise nature. A single example of a head in clay, possibly of this type but smaller, is present in Dr. Abbott's so-called "American Sphinx," a pottery head found on the Assiscunk Creek at or near Burlington, which is equal to many Iroquoian specimens.[2] Unlike any of the stone heads known to me, it shows the enormous ear ornaments described by Heckewelder and other early writers as used by the Delaware and Shawnee for the reception of which the lobes of the ears were slit and fearfully distended. If the face resembles that of an oriental, as Dr. Abbott thinks, we must look rather to the limitations of the maker's art and material than to any preconceived idea on his part due to contact, as Mr. Evarts Tracy is pleased to fancy.[3]

[1] See M. R. Harrington, "Vestiges of Material Culture among the Canadian Delawares," p. 416. (American Anthropologist, Vol. 10, 1908.)

[2] Abbott, C. C., "Ten Years' Diggings in Lenâpé Land," p. 29.

[3] Ibid.

For the handicraft of the modern expatriated Lenâpé, now in Canada and Oklahoma, our two chief sources of information are the collections in the American Museum of Natural History in New York, and the Museum of the University of Pennsylvania in Philadelphia. The collection in the American Museum represents the Munsee band, now in Canada, and the specimens in Philadelphia are largely from the Unami of Oklahoma. Both collections were made by Mr. M. R. Harrington of the Philadelphia institution, who is preparing a monograph on the Lenâpé, the fruits of several years' detailed study of the tribe. A few scattered specimens may be in the hands of individuals from whence it is to be hoped they, like the various archæological specimens, will find their way into some permanent museum to be carefully preserved for the benefit of the people at large, and as a memorial of those "long ago people," our predecessors, the Lenâpé Indians of New Jersey.

CHAPTER II.

Indian Camp Sites and Rock Shelters in Northern New Jersey.

By MAX SCHRABISCH.

POPULATION.

In the following paper mention is made of 370 aboriginal camp sites, villages and rock shelters in northern New Jersey and the enumeration is probably far from complete, being full in some parts and scanty in others.

The aborigines whom the whites found in undisputed possession of the present State of New Jersey belonged to the Algonkin stock. By reason of their laying claim to an ancestry more remote than that of any of the other Indian tribes they proudly called themselves Lenni Lenâpé, *i. e.*, original people. In view of the large number of aboriginal camp sites and villages to be found in northern New Jersey, one may be tempted to imagine that this territory was once peopled by large numbers of the Lenâpé. This, however, does not appear ever to have been the case. As a matter of fact, the historian Smith, flourishing about the middle of the eighteenth century, estimated the total number of Indians then living in the State of New Jersey to have been less than ten thousand.[1] If, then, the hypothesis of a thickly inhabited country falls to the ground, we may still satisfactorily account for the frequency of sites and of prehistoric remains by remembering, first, that the Indian was of a roving disposition, shifting his abode at frequent intervals within his allotted and narowly circumscribed hunting-grounds; and, second, that his occupation of the area in question extended, no doubt, through untold centuries, nay, many thousands of years. Accepting the latter theory as correct, the well-nigh astounding ubiquity of ancient remains does not seem in the least surprising, the sparseness of the Indian population notwithstanding.

[1] Some well-informed persons regard this number as probably considerably too large. H. B. K.

GENERAL CHARACTER OF SITES.

In looking for a suitable place to pitch his tent the redskin would naturally enough select a spot close to some water, be it river, brook, spring, lake or swamp. The site thus chosen had to be high and dry, that is, free from inundation, more or less level, and if possible well sheltered from north winds. Forks of brooks and rivers were usually looked upon with favor provided the lay of the land and, above all, the opportunities for hunting were such as to promise an easy sustenance. Shallow lakes and bays were preferred to deep water as affording the best fishing grounds, and the fords and rifts of rivers were chosen for the same reason. However, it is in the river valleys that the evidences of ancient settlements are most abundant, for the rivers were the natural avenues of communication, particularly at a time when the country was covered with an almost unbroken expanse of nearly impenetrable forest. In any event due regard was had to the soil. Highland or lowland, our aborigines always shunned a stiff clay when possible, and chose a sandy or gravelly loam. This was the common rule even in temporary camps.

FAVORED DISTRICTS.

Some sections in northern New Jersey are remarkable beyond all the others for the exceptionally large number of sites and the profusion of remains marking these scenes of prehistoric activity. And, to be sure, in considering the distribution of aboriginal sites in northern New Jersey, thus far explored and mapped, it is at once obvious that the various river valleys offer the most fertile field for archæological research. Foremost among these valleys is that of Delaware River. Of lesser importance, both in point of sites and remains, must be regarded the valleys of Pompton, Passaic, Saddle and Hackensack Rivers.

Delaware Valley.—As already stated, the Delaware River valley appears to have been the headquarters of the Lenni Lenâpé by reason of the many advantages offered by a water course of such dimensions. It is no exaggeration to say that its banks were dotted by an almost unbroken succession of camp

sites and villages, and nowhere in the State are the remains of their industry more plentiful or more diversified. In addition, it would seem that the implements found here are superior in workmanship to those of any other region within the State and, moreover, there is no lack of artifacts hereabouts that are exceedingly rare elsewhere, such as banner stones and pipes. Thus, it is certain that within the area watered by Delaware River the culture of the Lenni Lenâpé had attained a high point of perfection.

Pompton Valley.—This is another important section associated with Indian lore and the reminders of that vanished race. At its northern end it is watered by the Wanaque, Pequannock and Ramapo Rivers, which unite below Pompton forming Pompton River and joining Passaic River at Two Bridges. A thorough search of this region has revealed the presence of numerous camp sites and villages, showing that it was much frequented by the red huntsman. The largest village site in this valley is situated at Pompton Plains, and if we are to judge by the number and variety of the implements recovered at this spot it must have been the headquarters of the Pompton Valley aborigines. Lying about 1,000 yards from the foot of the hills bounding the plains on the west and 1½ miles from the banks of the Pompton River, this locality afforded indeed an ideal camping ground, sheltered, as it was, from north and west winds and with plenty of water conveniently near furnished by a brook and a swamp. Under these circumstances this site is found to be replete with many indications of prolonged occupation. Other village sites within this territory are at Pequannock, Wayne and Mountain View, all of them flanking the banks of Pompton River. That a well-trodden trail connected all these settlements, beginning at the Great Notch, a gap in the first Watchung Mountain, and passing through the Pompton Valley northward to Greenwood Lake, may therefore be taken for granted. At Pompton several other paths met, the most important being the Suffern trail, which ran along the base of the Ramapo Mountains, and the Butler trail passing in a westerly direction to Lake Hopatcong.

Passaic Valley.—Many a fishing place and camp site lined this once beautiful stream and the country through which it flows supported at one time a comparatively dense Indian population, for the river abounded in fish and the forest in game. That this region was the scene of busy life may be inferred from the fact that an important trail, the Wagaraw trail, traversed it on the Bergen County side of the river, connecting with the Goffle and Totowa trails at the northernmost point and bend of the river. The former ran north to Sicomac and Franklin Lake, the latter in a southwesterly direction to Totowa and thence to Singac, closely following the meanderings of Passaic River. Again, there are many indications of primitive workshops along its banks and here the surface soil is even now littered with raw material and flakes. Flint, quartz and jasper were the materials most highly prized and they were almost exclusively employed by the later or so-called modern Indians. Many facts apparently indicate that further back in time, argillite was mainly made use of, and this period has been designated as that of the argillite Indians. In still more remote ages primitive man rudely chipped his material and the products of his industry are called paleolithic, in contradistinction to the more recent ones, which are known as neolithic.

Aside from the remains of aboriginal origin left on the banks of Passaic River there are other evidences of the Indian's activity, such as fords and weirs crossing the river at various points and plainly discernible to this day, especially at low water-mark. Between Passaic Park and Two Bridges, a distance of about 20 miles, no less than sixteen fords or weirs may be distinguished, namely, one each at Passaic Park, Garfield, Clifton and Broadway bridge (Paterson), six more up the river to the Falls, four between Totowa and Singac, and two opposite Two Bridges. A peculiar feature of all these fords is that the rocks used in their construction are not laid across the river in a straight line, but are arranged so as to form midstream an angle, with the apex pointing downstream.[1]

[1] The fact that many similar rock fords and weirs have been constructed by white men must not be overlooked. The mere occurrence of V-shaped lines of rocks in streams cannot be regarded as proof of Indian workmanship without some independent evidence which shall differentiate them from those of the white man.—H. B. K.

A particularly good section within the Passaic Valley is that level tract of land, which lies 6 miles west of Paterson, with the village of Fairfield as its centre. This section is well sheltered to the north and west by Towaco or Hook Mountain, a range of hills consisting of two arms, each about 5 miles long and forming a right angle, the apex of which is at Towaco. Passaic River flowing along the southern and eastern base of this ridge and parallel to it also forms a right angle, thus likewise enveloping this section on two sides, viz., north and west. Within it there are many small swamps alternating with knolls high enough to be exempt from inundations in times of freshets. All these knolls bear witness to ancient occupation as evidenced by the numerous traces of primitive art. It was a stretch of land peculiarly suited to the tastes of the Redman. With wits sharpened by the iron laws of necessity he was always partial to places of this kind; hence, the remains of his industry reminding the white intruder at every turn of his erstwhile presence. The most important settlement of the Indians of the Fairfield region lay in the very corner of Hook Mountain on high land, called Tom's Point. Like a promontory it projects far out into the marshy lands, its southernmost point almost reaching Passaic River. The principal pre-historic highway hereabouts was the Caldwell-Fairfield-Mountain View trail. West of it another trail skirted along the eastern base of Hook Mountain between Pine Brook and Towaco, and also around the Great Piece Meadows in an easterly direction to Singac.

Saddle River Valley.—The banks flanking this easterly tributary of Passaic River tell an eloquent tale of ancient occupation. Again, the lay of the land justifies us in assuming that a trail wound along the western bank of this picturesque water course, beginning at Garfield and running thence in a northerly direction to Paramus and points beyond. While along this trail there are many traces of archæological significance, the opposite side of the river is likewise dotted with aboriginal sites.

Hackensack River Valley.—This section is likewise remarkable for the large number of ancient sites occupying the banks of the river and those of its tributaries. As, however, only a few

of these have thus far been determined and explored, no definite statements can as yet be made.

ROCK SHELTERS.

Apart from building his hut in the open, so to speak, by the banks of rivers, brooks, lakes or swamps, the Indian would, whenever possible, dispense with the work of providing an artificial shelter by availing himself of natural shelters, that is, rock formations affording more or less protection from the rigors of the climate. In this sense, then, he partook of the habits of the troglodyte or cave-dweller. As a matter of course, places of this description occur in mountainous districts only, in rough and broken country, where there are shelving rocks or overhanging ledges, which, if necessary, may easily be improved and made more habitable by leaning poles against the sides of the rocks and covering them with bark or skins. It is only within recent years that these rock shelters have attracted any attention, nay, their existence in these parts had, until a short time ago, hardly been suspected. Twenty of these natural shelters have thus far been discovered and investigated, all of them situated amid the foothills and mountains of northern New Jersey, and distributed as follows: Three on the east bank of Delaware River in Warren County, two of them being at the foot of Pahaquarry Mountain, near Delaware Water Gap, the other at the foot of Scott's Mountain and 3 miles south of Belvidere. In Passaic County, there are one at the foot of Kanouse Mountain, three in Upper Preakness, one on the slope of Federal Hill and three on Garret Mountain. In Morris County they are found one at the foot of Rock Peon Mountain (Bear Rock), three on the hills west of Pompton Plains, two in the corner formed by Towaco (Hook) Mountain. In Bergen County two occur in Ramapo Mountain and one east of Saddle River.

An essential requisite of prospective occupancy was water sufficiently near to suit the comfort-loving Indian. To be sure, all the shelters once occupied and hitherto examined were favored in this respect. When this condition was not fulfilled, the Indian would not use it, no matter what its other advantages

might have been. And, indeed, the writer knows many a fine rock house, large and comfortable, facing southward and affording ample protection against the elements, which was spurned and severely left alone obviously for no other reason than that water was too far away.

While most of these rocks served only as temporary dwelling places, as a sort of headquarters used before and after the chase to rest and feast on the spoils, some of the more accessible ones, *i. e.,* those not lying high up amid the mountains but at the foot of them, were more permanently occupied. While the former saw probably only male sojourners, the latter would harbor entire families, that is, husband, squaw and papoose.

The culture layers covering the floor of these rocks and representing the accumulated débris of ages have in every case been found undisturbed, and it is for this reason that important inferences as to a succession of culture horizons may be made. Since we meet here with the original conditions, that is, with such as existed at the time of the Indian's final departure, these rock shelters are quite unique and therefore exceptionally favorable to research along certain lines. As stated above, some of them lie far away from the beaten track and the camping grounds in the valleys below and to reach them required considerable physical stamina, more so at the time when the country was a vast wilderness. In these no traces of pottery were found owing to the difficulties of transportation; but wherever the débris contained fragments of pottery, these fragments lay invariably in the upper layers, a fact tending to prove that pottery was of comparatively late introduction.

CHAPTER III.

List of Sites, with Notes, Southern New Jersey.

By ALANSON SKINNER.

GEOGRAPHIC DISTRIBUTION.

A glance at the map of the Indian sites in south New Jersey, as far as reported, shows that they fall naturally into a number of groups, which are:

I. The New York and Raritan Bay group. This includes the remains on Staten Island and up South River. There must be more sites upon the Raritan and its affluents than have been reported.

II. The Atlantic Coast group. This includes the sites found along the coast from Sandy Hook to Cape May. It is evident that the Atlantic side of New Jersey was sparsely inhabited by the Indians.

III. The Lower Delaware Valley group. This includes the great Unalachtigo headquarters on Cohansey Creek, and the settlements in Salem County.

IV. The Middle Delaware Valley group. This centers in the cluster of sites at the Unami headquarters at Trenton and runs down below Camden. The inhabitants of this region were closely related to those of the New York and Raritan Bay group, who were also Unami Delaware.

It will be observed that the interior is practically devoid of sites, except on the headwaters of the more important creeks and rivers. This lends support to the tradition that the sandy interior of South Jersey was more of a hunting ground than anything else.

The readers of this report must remember that it represents but the work of a preliminary survey of two months' duration, and therefore, while much has been accomplished, the work is in

no way complete, and the conclusions arrived at are in no case final.

GROUP I, NEW YORK AND RARITAN BAY.

Constable Hook.—There is a village site with shell pits on the sand hills behind the Standard Oil Works on Constable Hook. The shell pits in this instance might more properly be styled mounds, since the surrounding sand has largely been blown or dug away, leaving them standing above the present surface. The writer has found a club head, arrow points, potsherds, net sinkers, sturgeon plates and fish and mammal bones in and near these pits. (26-23-8-8 and 9.) [1]

Greenville.—The writer has seen some potsherds daubed over with red paint, probably ochre, that were said to have been collected on a site on the point at Greenville. (26-23-5-2-7.)

Constable Hook.—A camp site on Constable Hook was located and reported by Mr. Leslie Spier. (26-23-7-1-9.)

Bayonne.—Camp sites occur on or near the shore of Newark Bay in Bayonne, near the foot of 25th street, along the Central Railroad, and at the tip of Bergen Point. (26-23-4-7-9; 26-22-9-6-2; 6-7.)

Carteret.—The writer once owned a grooved ax from Carteret, and other objects have been reported from there. (26-32-4-5-8.)

Elizabethport.—In grading streets in Elizabethport, near the shore, relics are said to have been found, but the exact locality is unknown.

Perth Amboy.—Graves and shell heaps were found by contractors in grading streets in Perth Amboy. There are arrow

[1] The system of numbering followed is that described in the Administrative Report of the State Geologist of New Jersey for 1911, Bulletin 6, pp. 13–15. Persons having the published topographical maps of the Survey, Nos. 21–37, can locate on them the exact sites by applying these numbers as there described. In brief, the system is as follows: The first number refers to the topographical atlas sheet; the second number to the major subdivisions of this sheet, each 6 minutes of latitude and 6 minutes of longitude, the numbers commencing in the upper left-hand corner of the sheet, the first tier being 1 to 5, the second 11 to 15, the third 21 to 25, etc.; the third number refers to one of the nine 2-minute rectangles making up the 6-minute subdivisions, the numbers commencing in the upper left-hand corner; the fourth number refers to one of the 9 equal subdivisions of the 2-minute rectangles; each of these subdivisions is still further divided into 9 parts similarly numbered, to which the last number refers.

points and other implements in the collection of the Staten Island Association of Arts and Sciences that were found in fields along the shores of Raritan River. Heckewelder tells of an old Dalaware Indian whom he met in Western Pennsylvania or Ohio in the early days of the nineteenth century who remembered catching rabbits to sell to the workmen employed in building Perth Amboy.

Staten Island.—Although not occurring within the political boundaries of New Jersey, the following sites on Staten Island, New York, are so obviously within the geographical limits of the survey that the writer has included them. They are valuable to us from an archæological standpoint in that they are remains of the same people with whom we have been working in New Jersey, and the absence of any number of Indian sites on the Jersey shore of the Staten Island Sound or Kill van Kull is due to the more favorable aspect of the Staten Island side of the narrow stream.

The Raritan, Hackensack and Tappan divisions of the Lenni Lenâpé, or Delaware Indians, were the original owners of Staten Island, and their presence is still well attested by many and rich sites. [1]

Pelton's Cove.—There was formerly an Indian village site and cemetery at Pelton's Cove which is now obliterated. (26-23-7-8-3.)

West New Brighton.—The cemetery situated on the grounds of Ascension Church, West New Brighton, occupies the site of a still older graveyard of the aborigines. Relics are still found occasionally when graves are being dug or improvements made. (26-23-7-8-4.)

Mariner's Harbor.—At Mariner's Harbor and westward along the shore to Howland Hook the early non-obliterated traces of a series of ancient Indian villages and camp sites may yet be seen. The writer and others have collected many hundreds of implements of stone, clay, bone and antler on these sites. (26-22-8-8 and 9 and 9-7).[2]

---

[1] For a detailed description see Alanson Skinner, "The Lenâpé Indians of Staten Island." (Anthropological Papers of the American Museum of Natural History, pp. 4–17, Vol. 3.)

[2] For a detailed account see Anthropological Papers of the American Museum of Natural History, Vol. 3, pp. 5–8.

Old Place Neck.—There is a large village site at Old Place Neck. Near the point are many traces of former lodge sites and refuse pits. A burial ground is reported and relics are abundant. Camp sites are to be found far back toward South Avenue. (26-32-2-2 and 3.)

Watchogue.—At Watchogue camps and relics are scattered over the sand dunes. The writer has found a few trade articles, such as brass arrow points, here. (26-32-3-4, 5.)

Chelsea.—There is a big camp site at Chelsea on the north side of Prall's Creek. (26-32-2-7-3.)

Linoleumville.—Village sites, shell heaps and scattered relics are found over a wide area at Linoleumville, on Long Neck. (26-32-5-1, 4, 2.)

Long Neck.—South of Long Neck, close to Fresh Kills, there is a little camp on the meadow island. (26-32-5-5-5.)

Lake's Meadow Island.—On Lake's Meadow Island south of Fresh Kills there is a village site. This place was once visited by Henry D. Thoreau, who found arrow points there. (26-32-5-7-1.)

Lake's Island.—Opposite Lake's Island a small camp site occurs on the mainland. (26-32-5-7-8.)

Rossville.—A shell heap and village site occur at Rossville near the post office and in the vicinity, wherever there are sandy knolls remains are found. (26-32-7-5-4.)

Woodrow.—At Woodrow a village site and obliterated cemetery have been identified. (26-32-7-8-3.)

Rossville to Tottenville.—Continuous camps occur along the shore from Rossville to Tottenville with scattered relics in nearly every field.

Tottenville.—A burial ground, immense shell beds, camps, villages, and scattered relics cover a wide area at Tottenville. This is the most important single site in a wide area.[1]

Mt. Loretto.—Small shell heaps occur along the shore near Mt. Loretto (26-42-1-8-7), also at Wolfs Pond (26-42-2-4-6), Seguines Pond (26-42-3-1-7) and Great Kills (26-33-7-5-5). Scattered relics are found in many nearby fields.

---

[1] See Anthropological Papers of the American Museum of Natural History, Vol. 3, pp. 11–16.

Arrochar.—There are scattered relics and camp sites at Arrochar.

Silver Lake.—Camp sites occur at the northwest and southwest ends of Silver Lake (26-33-2-1-2; 1-4) and scattered relics on Pavilion and Wards Hills, Tompkinsville. (26-23-8-8-8, 9.)

Valley Lake.—Camp on Nannyberry Hill near Valley Lake. (26-33-1-6-2.)

There are other sites on Staten Island, but the foregoing list gives the most important ones.

Near South Amboy.—At Morgan along the bluff on the north bank of Cheesequake Creek there was formerly an immense shell heap, village site, and burial ground, which is now largely destroyed by grading for the railroad. A number of skeletons were dug out by the steam shovel, and refuse pits and fireplaces were exposed in some numbers. It is reported that relics were found with skeletons in a cemetery nearby. This is unusual in New Jersey, as the only other finds of like nature that are so far reported were made at Chestnut Neck, near Columbia, and in the Indian cemetery at Burial Ridge, Tottenville, Staten Island, nearly opposite and in plain sight from Morgan. (28-1-3-1-1, 5.)

Morgan.—Large heaps of shell are visible along both sides of the road to Keyport on the opposite side of Cheesequake Creek from Morgan. They contain few relics and do not seem to extend to the bluff overlooking Raritan Bay. (29-1-3-2-8.)

Camp sites and scattered relics are also reported from other points in the neighborhood of Cheesequake, but their exact location is unknown.

Marquis Creek.—There is a small shell heap on the bank along Marquis Creek (29-1-3-6-4), a camp site on the high point east of the creek (29-1-3-6-5), and two small camp sites close together near the bay (29-1-3-6-3). At the latter oyster shells and flint chips abound.

Cliffwood.—A small camp site with flint chips and shells lies north of Cliffwood near Whale Creek (29-2-1-4-9). On the bluff above Matawan Creek opposite Keyport there is a large heap of shells containing few relics (29-2-1-9-1). It is apppar-

ently a place where the Indians dried shell fish, but had no permanent settlement.

Keyport.—Shell heap at Keyport near Conaskonck Point, described by Charles Rau.[1] Many implements have been found here, including some clay beads, a type of relic not reported from any other New Jersey site, and of which the writer has no knowledge except as occurring on the Iroquois site at Hochelaga, Montreal. Possibly Mr. Rau erred in the identification of some broken pottery pipestems which are not rare on such sites. (29-2-2-5-9 and 6-7; -7-5.)

Sayreville.—There is a village site among the sand dunes along South River near the Sayreville clay pits. Fireplaces marked by burned earth and heat-cracked stones are abundant. Over the surface are strewn countless flint chips and potsherds, while arrow points and other implements are not rare. Quantities of small burnt pebbles still lying in heaps seem to indicate the location of ancient sweat baths. (28-5-1-4-8.)

South River and Old Bridge.—The following sites lie north of Old Bridge on the east side of South River beginning at the north near the Raritan River Railroad. The exact location of each is indicated by the numbers.

An old, nearly obliterated village site where potsherds, arrow points, and the like, are still to be found. In a sand pit near the river the writer has found an excellent celt and some finely decorated pottery fragments (28-5-1-5-7).

Camp sites near the second brook south of the railroad were noted. Flint chips and arrow heads were abundant. (28-5-1-8-1.)

A village site with some nearly obliterated fireplaces and shell pits. In the latter the writer has found European glazed pottery, glass, and nails, mingled with flint chips, Indian potsherds, and other aboriginal traces. (28-5-1-8-4.)

A small village site, nearly obliterated. Here the writer has obtained some interesting specimens including a notched ax. (28-5-4-2-1.)

---

[1] Annual Report of the Smithsonian Institution for 1884 in a paper entitled "Artificial Shell Deposits in New Jersey," pp. 370–374.

Second small site nearly connected with preceding, much débris, such as flint chips, from arrow making. (28-5-4-2-2.)

Large village site. Arrow points, chips, pottery. (28-5-4-2-5.)

Scattered relics are found between all the sites in this vicinity.

Large much-used site 1½ miles northeast of Old Bridge, now destroyed by the railroad, except on the edges (28-5-4-2-9). A small village site occurs a little southwest of this point (28-5-4-5-3).

Runyon Pond.—There is a large village site beside Runyon Pond. Arrow points, pottery, a pestle, axes, and other relics have been collected hereabouts. Men employed in digging artesian wells for the waterworks have informed the writer that skeletons were exhumed during this work many years ago. (28-5-4-3-6.)

Old Bridge.—A village site with scattered shells and relics occupies the east bank of the river. (28-5-4-4-6.)

Deep Run.—Near Deep Run, east of Old Bridge, a large area among the sand hills shows indications of former habitation, but only a few relics have been noted. (28-5-4-5-8.)

Iresick Brook.—Many camps and scattered relics occur along Iresick Brook, south of Old Bridge.

Few if any of the Sayreville, Runyon, or Old Bridge group of sites will repay excavation. The shifting of the sand in the wind has uncovered most of their treasures to the gaze of the passerby with the inevitable result that very little has been left. The sites themselves are slowly becoming obliterated.

Matchaponix.—Mr. Wm. T. Davis of Staten Island reports a village site near Matchaponix. (28-14-3-6-7.)

Jamesburg.—Mr. Davis also reports a camp site on the shore of the lake at Jamesburg. Doubtless other sites are abundant along Manalapan Brook. (28-14-2-4-7.)

Matawan.—Mr. Waldron de Witt Miller of the American Museum of Natural History of New York, has located and reported a camp site in "Thirteen Oak Forest," 4 miles southwest of Matawan. (29-1-8-4-7.)

Oceanic.—Mr. Leslie Spier reports a camp site an acre in extent on the bank of a small brook east of Oceanic, at which shells are fairly abundant. (29-4-7-9-2.)

GROUP II, ATLANTIC COAST SITES.

Belmar.—Mr. Wm. S. Yard, of Trenton, obtained many implements through workmen who found them in grading Belmar streets in what is now an obliterated village site. Among the specimens is a polished grooved ax said to weigh twelve pounds.

Manasquan.—Mr. C. E. Seage reports that scattered specimens have been found on the point of land at Brielle and Manasquan (29-33-6-5, 8). Scattered relics are found on the points of land between Manasquan and the ocean front.

Point Pleasant.—Mr. Seage reports that implements have been found in the borough of Point Pleasant, but exact locations are not given.

Mantoloking (?).—"In the extreme upper end of Barnegat Bay, and on the west side, is a piece of land, a sandy spit, projecting into the bay, known to many people in the neighborhood as the site of an old Indian camp, and where a great deal of pottery, etc., has been found. * * * The spot referred to is said to have been a camp for Indians when they went to the shore for fish and oysters." Reported by Mr. Wm. J. Lovell, of Moorestown, N. J. (29-43-3-7-2 ?)

Burrsville.—Two miles east of Burrsville, a sand hill on the Metedeconk River is called "The Indian Stage," and is so referred to in the old deeds and records. Here is the site of an Indian village where A. C. B. Havens, of Toms River, has found relics. (29-43-1-3-7.)

In the Orchard Field between Burrsville and Wardel's Neck is a very much used Indian village site. Mortars and other fine specimens have been found. (29-43-1-1-1.)

Beaver Dam Creek.—A very interesting causeway of logs is situated on the Indian trail that ran parallel to the coast from north to south. It is on the south fork of the south branch of Beaver Dam Creek, and is a raised pathway of logs which was certainly not made by the settlers. There are said to be similar causeways on the same trail further to the south.

Pumpkin Point.—On Pumpkin Point, Toms River, and nearly on what is now the property of John P. Haines, Indian relics

were formerly found during spring ploughing. (33-2-4-6, and 4-4.)

Island Heights.—At Island Heights, a village site and cemetery were found in grading streets. These are now destroyed. (33-2-6-8-1, 2.)

Ocean Grove.—There are camps on the Grant farm at Ocean Grove. (33-2-5-9-6.)

Toms River.—Traditional Indian burial ground on main branch of Toms River where an old mill road crosses near the bridge. Nothing now to be seen, however. (33-2-1-4-3.)

Mosquito Creek.—There is a camp on the knoll at the mouth of Mosquito Creek.

On David G. Clayton's farm, 3 miles northeast of Toms River, there is said to be a large camp site, with circles of dark earth about 30 or 40 feet in diameter. This is thought by the residents to have been an old dancing ground.

Pine Beach.—Shell heaps on the point near the hotel at Pine Beach, southeast of Island Heights.

Barnegat.—There are two small shell heaps at Barnegat on a point running out towards the salt meadow. On visiting them the writer found potsherds, chips, and a very small pitted hammerstone. (33-22-4-6-7.)

There is a small shell heap on a point near the brook below Barnegat (33-22-9-9-5) and a smaller shell heap 100 feet from the last (33-22-9-9-1). A large shell heap, apparently very thick, extends all over the point. In the sandy fields nearby potsherds are fairly common. There is another smaller heap at hand (33-22-9-9-5). A very small shell deposit is bisected by the road (33-22-9-9-2). A shell heap, apparently large and thick, seems to cover a small rise in the meadow, but mosquitoes and vegetation rendered careful examination impossible (33-22-9-9-7). Mr. Clarence Woodmansie, of Barnegat, reports a shell heap on the point between Waretown and Barnegat (33-22-2-7-8).

Ostrom.—A very small shell heap lies on the upland near the edge of the meadow on Forked River at Ostrom. The writer

was unable to determine absolutely whether it is Indian, though the locality makes such an origin highly probable. (33-12-8-1-8.)

Forked River.—There is a shell heap on Forked River near the salt meadow. The exact locality was not given when this site was reported.

Waretown.—A camp site is reported in the woods northeast of Waretown. (33-22-2-1-3.)

Waretown Creek.—There is a shell heap on the edge of the meadow just south of Waretown Creek. (33-22-2-2-4.)

Mayetta Station.—Near Mayetta station the railroad cut exposes a very small shell bed. (33-31-2-9-4.)

West Creek.—In the town of West Creek there was a village on Cox's farm. A dug-out canoe was found, and a skeleton with implements exhumed. (33-31-4-9-7.)

The following item appeared recently in the "New Jersey Courier":

"The first road from Toms River to Lakehurst," said Mr. Irons, "was the 'old Indian trail', from Toms River to the Delaware River. The road to Lakehurst followed this trail to the New Furnace, the trail running up the east side of Toms River to that place. New Furnace was built by Samuel G. Wright somewhere about 1800, and was two miles northeast of Federal Furnace, afterwards Manchester, and now Lakehurst." As near as Mr. Irons could recall the straight road to Manchester via Wright Bridge must have been built about 1830.

"Naturally, the talk of the Indian Trail recalled the fact that over on the northeast of the village on the Manasquan road, is Indian Hill. Mr. Irons said that he had been told as a boy that it was named that because Indian Will, a straggler from the tribe, lived there under the hill for a long time. The Indian's hut stood, as he had been told, just under the hill on the place where the father of B. F. Pierce afterward lived."

We are also indebted to the editor of the "Courier" for the following:

"While working on the new road to the Long Beach Turnpike Company's bridge, at the Manahawkin end, the workmen

unearthed two skulls, supposed to be Indian. The peculiar feature of the discovery was that the skulls were complete, lower jaw and all. The skulls were found buried about three feet deep in what is known as Boat House Knoll at Company Landing. They were taken by William Bennett, who still has them in charge."

Another correspondent writes that there were four skeletons in all unearthed while plowing up the new road, and that "the heads were the most perfect part, all the teeth being in the jaws on several."

Tuckerton.—There is, on the property of the Jillson brothers of Tuckerton, a shell heap and a burial ground in which were found thirty-two skeletons. Eighteen of these were buried in one trench. The position of the bones was such as to lead the discoverers to believe the Indians to have been the victims of a massacre or pestilence. One woman had a child laid across her breast, another skeleton lay over the bones of a woman flung beneath it, and the remains of a child lay between her knees. Many of the bones showed breaks or other injuries. The only relics were a small trumpet-shaped clay pipe, with incised decoration on the bowl, which lay close to a skull as though it had been thrust in the owner's hair, and a stone pendant or single-holed gorget that lay on an infant's breast. (32-44-4-4-8.)

There is an immense shell heap on the salt meadow at Tuckerton, visible for miles, as it stands above the surrounding level and is covered with trees. The late Dr. Frank Hamilton Cushing of the Smithsonian Institution visited this mound, and made some preliminary investigations, finding traces of a pile village in the salt meadows close by. His death interrupted his work, which has never been completed. (32-45-1-8-9.)

There is a cemetery in Tuckerton on the Sapp Farm. (32-35-7-9-8.)

Wells Island.—There are shell heaps on Wells and Osborne Islands, and scattered implements. (32-44-6-4,5.)

Chestnut Neck.—A large village site and cemetery on Chestnut Neck opposite New Gretna. Messrs. Jillson of Tuckerton have partially explored the burial ground, finding seven

skeletons, most of which had buried with them a quantity of arrow points and raw material (jasper) for their manufacture. With one was found a fine large monitor pipe of steatite. (32-44-3-7-7, 8.)

Pleasantville.—Pleasantville now occupies an old Indian village site, relics have been found all about, especially some fine banner stones. There are said to be shell heaps along Dowdy's Creek behind Atlantic City. (36-13-5-1-9.)

Smith's Landing.—There is a large shell heap at Smith's Landing on the shore near Pleasantville, located by Leslie Spier. (36-13-5-4-6, 9 and 5-4.)

Mt. Pleasant.—A camp site at Mt. Pleasant an acre in extent. It is located at the source of a branch of Absecon Creek. Arrow points were reported from this site. Located by Leslie Spier. (36-13-5-2-2.)

Leed's Point.—Scattered shells on Leed's Point indicate Indian occupation. Reported by Leslie Spier. (36-4-5-1-6.)

Port Republic.—Spier reports indications of occupation all along Nacote Creek, and a shell heap east of Port Republic. Axes and arrow points are said to be fairly abundant. The absence of potsherds on this and all other sites reported by Spier is notable. He concurs with the writer in believing that most of the east-coast sites were temporary fishing stations. (36-3-3-5.)

West Cape May.—A site is reported at West Cape May by Dr. C. C. Abbott. Here were found a number of objects, including a bead beaten from a nugget of native gold. (27-11-3-7-2.)

Holly Beach.—At Holly Beach there was a site, now obliterated, where many relics were gathered. (37-2-9-5-2.)

Dennisville.—There was a large Indian village where Dennisville now stands. Several caches of implements are reported, and there are said to be shell heaps all along Dennis Creek at the bends. (37-34-6-1-6.)

Tuckahoe.—Specimens have been reported from Tuckahoe and vicinity. There are probably shell heaps all along the bends of Tuckahoe Creek. (37-21-4-1-6.)

Flat Creek.—There is a shell heap on Flat Creek near Great Egg Harbor. (37-22-4-5-3.)

Great Egg Harbor.—Prof. F. W. Putnam and Dr. C. C. Abbott found traces of prolonged occupation on Great Egg Harbor. At Somers Point, directly opposite, there is presumably much more, as this place has a southern exposure and more favorable conditions prevail. It was too heavily forested when last visited by Dr. Abbott to permit any observations. (37-22-4-3 and 5-4.)

Port Elizabeth.—There is said to be an extended settlement along the creek at and near Port Elizabeth. (37-23-1-3, 5, 6 and 8.)

Cape May Court House.—Frank Leaming of Cape May Court House has a conch shell cup and other specimens from a sand dune in the woods on Coxalle Creek on the Delaware Bay side of Cape May. He says there are very few sites on the west shore. This site is near Town Bank where the first settlement in Cape May County was made in 1680 or thereabouts. (37-1-8-2-1.)

There is a group of sites, probably all more or less connected, around the headwaters of Crooked Creek at Cape May Court House. Shell heaps, village and camp sites are all apparent, but were hard to distinguish when visited by the writer because of the thick vegetation. Shells, chips, potsherds, and fire-cracked stones abound. The writer was unable to locate a cemetery supposed to be near Cape May Court House. (35-44-6-3-7 and 8; 5-2; 5-6; 5-7; 5-8.)

At Joe Holmes' place there are three or four shell heaps which local authorities think represent seats of the wampum industry. There is some reason for this belief, as the shells are broken into small angular fragments like those found in the shell heaps of Long Island, New York, that are known to be made up of wampum refuse. There is also historical evidence in favor of this hypothesis. (35-45-4-1-4 and 7.)

Nummy's Island.—On Nummy's Island tradition states that the last chief of the local Indians is buried. After his funeral the Indians are said to have left for Wabash River. I have never

seen an Indian burial in a salt meadow, and such Nummy's Island appears to be. (37-3-1-7 and 4-1.)

Avalon.—On Ben Godfrey's place on the road to Avalon there is a large site from which Mr. Frank Leaming of Cape May Court House, has specimens and pottery. Mr. Leaming considers this the best site he has seen in the county. (35-45-1-3-6.)

All the shell heaps along the coast are characterized by a dearth of instruments, at least on the surface. A few tiny potsherds and chips may be found. Deer bones, charcoal, and fire-cracked stones seem from a superficial examination to be almost totally wanting. Local tradition everywhere states that the main Indian settlements were along the valley of the Delaware and its tributaries, especially on the New Jersey side, and the results of this survey seem to bear out this story. All the river sites produce enormous quantities of implements and show signs of extensive occupation. The coast remains are chiefly camps and shell heaps with few relics. There are no doubt, many more sites on the coast as yet unreported.

GROUP III, LOWER DELAWARE VALLEY.

Manumuskin.—Opposite Manumuskin station on Manumuskin Creek, the railroad cut has exposed quantities of potsherds, chips, shells and fire-cracked stone indicating a large camp or a small village. (35-13-7-9-6.)

Small camps on Manumuskin Creek near the railroad cut. (35-13-8-7-8.)

Port Norris.—Camp ground near Port Norris just west of the railroad track; scattered relics near at hand. (35-22-9-7-1, 2, 3.)

Stone axes, arrow points, potsherds, etc., are found on the points southwest of Port Norris post office. (35-22-9-7.)

Leesburg.—Scattered relics reported at Leesburg. (35-23-7-2.)

Cohansey Creek and Vicinity.—Along Cohansey Creek, in Cumberland County, there is a nearly continuous string of sites of all kinds for about 20 miles, mostly on the south side of the stream. The group probably represents the headquarters of the

Unalachtigo band of the Lenni Lenâpé, as the Trenton group represents the Unami, and the Belvidere sites the Munsee. The writer is indebted to P. K. Reeves, Edmund Shimp and R. W. Emerson, of Bridgeton, for information and assistance in visiting and locating these remains.

Cohansey Creek Sites.

Harrow Brook.—There is a good village site on Harrow Brook near Deerfield Street. (34-4-3-6-9 and 9-2, 3.)

Beebe Run.—Relics north of Beebe Run (34-4-6-5-7) and relics also occur at the mouth of Beebe Run (34-4-6-7-3).

Barrets Run.—Camp and relics on Barrets Run near Shiloh and at the mouth of the stream. (34-4-8-4-8.)

Cornell's Run.—A few specimens occur in the woods on Cornell's Run. (34-5-7-1.)

Bridgeton.—On Stone Bridge Run, north of Bridgeton, scattered relics occur (34-5-7-4, etc.). On a village site opposite Bridgeton, R. W. Emerson of that city has collected three stone mortars; on the west side of the creek as far as Cedar Grove there are scattered relics (34-4-9-9-5, 8). Some fine specimens were found on the brook above Irving St. Station, Bridgeton (34-5-79-4, 5.) Also, relics are found on a nameless run east of Bridgeton (34-5-7-8 and 6).

In the southern outskirts of Bridgeton is an old site where no implements except large-stemmed blades of argillite are found. Neither pottery, points nor hammerstones have been collected. This seems to have been a spot utilized as a camping ground by the argillite-using predecessors of the Lenâpé. (34-15-1-4-7.) Five hundred yards or less from the last-mentioned locality is a site from which many triangular points of quartzite have been gathered, but where no argillite implements occur. The ground is black from débris and decayed animal matter accumulated during long occupation (34-15-1-7-1).

Scattered relics were found along the point down as far as Parvin Branch (34-15-1-7-4 and 5). At a small camp on Parvin Branch potsherds and many flint argillite and jasper points

occur (34-15-17-8). A village site occurs at the mouth of Parvin Branch on the south side where many large argillite points, drills and axes have been collected. Relics are scattered along the south side of the branch east from here. At 34-14-1-8-4 a solitary cache of 60 large yellow jasper bevelled blades was found (34-15-1-7-6 8). At the foot of Doneghy Street there is a large site. Many relics have been collected here, several fine pestles among them (34-15-1-3, 6).

Fairton.—A village site in the woodland near Fairton is noted for the quantity of argillite chips and specimens. Scattered relics connect the camps which are to be found on all the knolls (34-15-4-4-3, 6 and 1-9). At Fairton relics are scattered along both sides of Mill Creek and its tributary. (34-15-4-5, 6, 8.) West of Fairton, along the south side of Cohansey Creek, is a continuous string of sites from which thousands of implements have been obtained. Potsherds, chips and arrow heads innumerable litter the surface. All types of specimens occur, perforated stones, clay pipes (usually fragmentary), broken and perfect gorgets, bannerstones, arrow-shaft smoothers, grooved axes, celts, pieces of soapstone vessels and other things. are abundant. (34-14-5-9-1, 2, 3 and 6-7-1, 2, 3, and -8-1, 2, 3, and 9.)

Tindells Landing.—At the head of Back Creek, and 2 miles southwest of Tindells Landing, is a field which was long occupied by the Indians. Here is an exceedingly rich deposit of black earth throughout which countless deer and other animal bones, potsherds and other débris can be found. Edmund Shimp, of Bridgeton, once counted 80 or more shell and fire pits exposed by a spring ploughing. Mr. Shimp has collected three bone awls and a bone arrow point (made from a scale of *Lepidosteus ferox* of the Mississippi River) from one of these shell pits. A perfect clay pipe in his collection comes from a field close at hand. On a knoll touching the site skeletons have been disinterred, and to the east the sand hills show prolonged occupation. Flint and quartzite chips betray the presence of workshop sites and potsherds abound.

On August 4, 1912, the writer visited this site under the guidance of Messrs. Shimp and Emerson. Scratching a single

hole with trowels and a shingle yielded a fine notched bone awl, a clay pipestem, dozens of fish, bird and mammal bones, chips and potsherds. On one of the sand dunes to the eastward most of a pottery kettle, cracked in Indian times, and mended by making a row of perforations along each side of the flaw and lacing the break together with a thong, was found. (34-14-8-3 and 9-1.)

Cohansey Creek.—Scattered relics occur along Cohansey Creek beyond Green Swamp on an old farm and as far down as the upland runs to Back Neck. (34-14-4-7-1, 2, 5; 5-7, 8, 9, and 6; 6-7, 8 and 34-14-7.) On the west side of Cohansey Creek enormous quantities of specimens have been gathered all the way to Dutch Neck, and turning the bend, on as far as Greenwich. (34-14-3, 4, 5 and 6.)

Greenwich.—At Greenwich there is a rich site on the west bank of Molly Wheaton Run. Quartzite chips abound. and a quartzite quarry occurs in one of the fields by the side of the stream. Two grooved stone mauls, one made of quartzite, the other of argillite, were found here by Shimp and Emerson, and there can be no doubt but that they were used in the quarry. Scattered relics are found along the bank as far as the spot where the run enters the Cohansey. (34-13-6-3.)

Sheppards Mills.—There are two small camps on Mounces Creek near Sheppards Mills. (34-14-1-8-8.)

Othello.—A small but rich site is situated at Othello, north of Greenwich. Jasper, quartzite, and flint implements, many fragments of pottery pipestems, decorated potsherds and numerous tiny triangular points of superb workmanship have been gathered. (34-13-3-5 and 6.)

Davis Mills.—Scattered remains occur around Davis Mills, on the shores of the pond and stream. (34-13-1 and 2.)

Seventh Day Mills.—Small camp in the woods near Seventh Day Mills. Potsherds and arrow points (34-4-4-8). Scattered remains occur near pond at Seventh Day Mills. (34-4-4-8-1 and 2.)

Mickles Mills.—Scattered remains on Sarah Run below Mickles Mill. (3(4-3-5-6-3.)

Jericho.—Scattered remains occur at Jericho. (34-3-5-9.)

Long Branch Run.—Relics occur on both sides of Long Branch Run. (34-3-9-1.)

Large camp opposite 34-3-7, with many large points was reported. (34-3-7-3-1, 2, 3, etc.)

Stow Neck.—Relics occur all over Stow Neck along the shores of Stow Creek.

Cumberland Causeway.—A camping ground runs from the road to a point on the shore of the pond where the Cumberland Causeway crosses. Perhaps this was a battlefield, as triangular, so-called "war points" are found in great quantities.

Stow Creek.—At Wood Landing on Stow Creek there is a large boulder once utilized by the Indians as a permanent mortar. In its deep cavity a bucket of water can be held. (34-3-7-6-7 and 8.)

Stow Point.—A burial ground on Stow Point where Mr. Shimp has found skeletons buried at depths varying from a few inches to 5 feet from the surface. Many relics were found on the surface, but one only, a crude ax, was obtained in a grave. (34-13-1-1-3, 6 and 2-1.)

Maskall's Mill.—Big camp or village all around the pond at Maskall's Mill. (34-3-4-3, 6 and 5-4.)

Quinton.—There is a large village site at Quinton on Alloway Creek. (30-43-4-5.)

A village site is opposite Quinton and scattered relics along both banks of the Creek to Alloway. (30-43-4-5.)

The "last Indian" in this region was buried near Alloway about 1820. His body was exhumed recently and stone implements found in his grave.

Hancock's Bridge.—There is a village at Hancock's Bridge on Alloway Creek whence Mr. Shimp has fine specimens. (34-2-3-7-4.)

Village all along the upland on the south bank of Alloway Creek, from Hancock's Bridge to the road. (34-2-2-9-8 and 6.)

Alloway Creek.—Camp on a knoll near Alloway Creek. Relics scattered all along both banks of the creek. (34-2-2-8-7.)

Salem.—Several hatchets were pumped out of the creek

bottom at Salem when dredging, and much material has been reported from the vicinity of Salem. (30-42-2-8-3.)

Lower Penn's Neck.—There is a village on Mr. I. O. Acton's farm on Lower Penn's Neck. (30-32-8-1-6.)

Churchtown.—A burial occurs north of Churchtown. (30-32-1-9-2.)

Mannington Creek.—A series of seven burial places along Mannington Creek and Swedes Run from Salem Creek to Alloway Junction. (30-32-9-6-2; 9-2; 8-6; 30-33-7-5-7; 8-2; 9-6; 30-43-2-1-3.)

Welchtown.—Near Welchtown on Mannington Creek is a village site. (30-33-7-9-7.)

Harrisonville.—A camp site covering about 2 acres is situated on the Tigh farm on Oldmans Creek immediately south of Harrisonville station. At this place there is said to have been a boulder hollowed out to a depth of 9 inches which is thought was probably used as a cooking utensil but was more probably a stationary mortar. This was removed several years ago. (30-34-1-2-2.)

Pedricktown.—Dr. Abbott reports remains at Pedricktown on Oldmans Creek. (30-23-4-3-6.)

Mullica Hill.—Mullica Hill village on Raccoon Creek occupies the site of an old Indian settlement. (30-25-4-7-6.)

Bridgeport.—Many objects are reported from Bridgeport by Dr. Abbott. (30-13-9-8-7.)

Swedesboro.—About one-quarter of a mile below Swedesboro station in the railroad cut is a layer of camp refuse 1 foot below the present surface. (30-24-4-5-8.)

Mr. Acton has reported a series of five burial places extending from Bridgeport to Oldmans Point along Delaware River. (30-23-1-7-1; 1-4-9; 2-1-4; 2-2-2; 3-9-7.)

Gibbstown.—Scattered remains were found below Gibbstown on Repaupo Creek. (30-14-7.)

Thompson's Point.—A burial at Thompson's Point (near the site of the Du Pont powder works) where many teeth and a jaw bone were dug up is reported by Dr. George Laws, of Paulsboro. (30-14-4-9-2.)

Glassboro.—Implements have been found in the sand pits at Glassboro. (31-21-9-8 and 3-3.)

Mt. Royal.—A number of finely worked and polished articles, including a bird amulet, a monitor pipe, and wampum have been found at Mt. Royal near Clarksboro. (30-15-7-6-9.)

Mantua Creek.—Scattered relics occur all along Mantua Creek. (30-15-4 and 7.)

Paulsboro.—Dr. Abbott reports remains, and Mr. I. O. Acton, a village site, at Paulsboro. Specimens are found on all the points along Timber Creek for a couple of miles back from the river. (30-14-9-3.)

Paulsboro.—Cache of small jasper leaf-shaped blades on Locke's place, 1½ miles below Paulsboro. (30-14-9-1-8.)

A burial is reported 1 mile north of Paulsboro about 2 feet deep and covered with a layer of broken stone. (30-14-6-9-3.)

Mantua Point.—At Mantua Point a pot, 16 inches in diameter at the mouth, rough argillite celts, and knives, banner stones, and great numbers of flakes and rejects were found. (30-15-4-4-4.)

Billingsport.—Dr. Abbott reports a village with abundant remains at Billingsport. (30-14-6-6.)

Woodbury Creek.—All along Woodbury Creek scattered remains are found. (31-11-4 and 5.)

Tradition reports that the Wood family burial ground near the mouth of Woodbury Creek at a place where the Indians interred their dead before white men came into this region. In September, 1912, there was no sign of the former presence of Indians at this place. However, this point of land is an ideal one for such a purpose. (31-11-1-8-9.)

Red Bank.—At Red Bank is a camp covering a considerable area. Fire-cracked stones, flakes, and rejects were found in abundance. (31-11-1-8-9.)

GROUP. IV.—MIDDLE DELAWARE VALLEY.

Pensauken Station.—Scattered relics on south branch of Pensauken Creek, due east of Pensauken Station. (31-2-6-5-3.)

Hellings Hill.—Mr. Chambers reports scattered relics on the north branch of Pensauken Creek from Lenola to Hellings Hill with village sites at the Evesboro road and at Hellings Hill. (31-3-8-3 and 31-4-7-4.)

Fellowship—There is a burial near Fellowship on the south branch of Pensauken Creek. (31-3-4-9-4.)

Moorestown.—At Indian Spring, near Moorestown, are scattered remains. (31-3-2-7, 8, 9.)

South of Moorestown is a village site. Implements of all kinds were found here in abundance, showing an extended occupation of this region. Occurring in the same layer and mixed with the implements usually associated with the historic Indian are many crude argillite blades. Harry Chambers, who has located and reported this site, has several rubbed argillite implements, heart-shaped, with short stems. A number of steatite pots were found nearby. (31-3-5-3-7.)

Riverton.—Scattered relics are found between Riverton and Palmyra.

Mt. Laurel.—All about Mt. Laurel are signs of an extensive camp site. Axes, arrow points, wampum (?), and pottery are ploughed up here. A small pot of Algonkin type about 6 inches in height and 6 inches in diameter at the mouth was found by Mr. Chambers. (31-4-4-7-9.)

Brown Station.—Camp site near Brown Station. Axes, arrow points, etc., are found along Haynes Creek. (31-5-4-4-7 and 31-4-9.)

Lumberton.—Scattered relics are found on the banks of Rancocas Creek at and near Lumberton. (31-4-6-3-1 and 2.)

Centerton.—A cache near Centerton, reported by Mr. Harry Chambers, of Moorestown, contained about two dozen net sinkers and several other implements. (31-4-1-2-2.)

Mt. Holly.—Scattered implements, etc., occur at Mt. Holly and along Rancocas Creek and its south branch. Excellent trumpet-shaped pottery pipes have been found in the vicinity; one in the possession of Mr. Wm. Wright, of Mt. Holly, is decorated with representations of deer. (31-4-2, 3.)

Wood Lane.—Camp site at Wood Lane on headwaters of Assiscunk Creek. (27-44-6-6-5.)

Burlington.—There is a large village site at Burlington on Assiscunk Creek. (27-34-8-3.) Abbott obtained a collection from this spot, including the remarkable modeled clay head described by him in his "Ten Years' Diggings in Lenâpé Land." The whole of Burlington Island is a large Indian village site.

Assiscunk Creek.—Several camp sites were located by the writer along the south side of Assiscunk Creek. They contained nothing except quartz and flint chips, fire-cracked stones and a few potsherds. These indications probably mark the location of a few isolated wigwams. (27-34-8-9-4.)

Rancocas Creek.—Scattered remains occur on Rancocas Creek opposite Bridgeborough and at Rancocas. Great quantities of argillite implements are reported to be found elsewhere along the banks of the creek.

Bordentown.—There is a camp or village 1 mile east of Bordentown at or near the forks of the brook (28-31-3-4-9.) There is said to have been an old camp or village site at the mouth of Blacks Creek in Bordentown. (28-31-2-5-8).

Indian Mills.—Just below where the Indian Mills Brook crossed the road 1¼ miles northwest of Indian Mills is the cemetery used by the Indians inhabiting the old mission settlement of Edgepillek. The last survivors were removed to New York, probably to the Seneca Reservation at Cattaraugus, about 1820. (32-31-1-1-2.)

New Egypt.—On Crosswicks Creek, south of New Egypt, and at Brindle Park are scattered implements. (28-43-1-3; 5-1, 2.)

The following note appeared in the "New Jersey Notes" in the *New York Sun* during August, 1912: "Clifford Horner, while working in Frank P. Gabel's cranberry bog near New Egypt, unearthed an Indian mortar and pestle. They are of flint and show signs of hard usage." (28-33-8-7-7.)

Walnford.—Abbott reports a village site at Walnford on Crosswicks Creek, where objects are very abundant. (28-33-2-7-8.)

Prospertown and Vicinity.—In the neighborhood of Prospertown and north towards Red Valley is a group of camp sites all

very much of the same type. Several have been long and frequently inhabited, but none have the accumulated débris of true villages. In nearly all of them circles of burnt stones that outlined the fireplaces still mark the sites of wigwams. F. W. Emley, to whom the writer is indebted for guidance to these sites has a collection from them consisting of several grooved axes, a small adze, two broken gorgets, and many arrow points. One of the latter is apparently carved of soapstone, and has a perforation, rimmed from both sides, in the stem. It was doubtless a charm or ornament designed for suspension. Mr. Emley has also an old pouch of dyed buckskin ornamented with colored porcupine quills and deer hair. Old metal "jinglers" and tassels of red-dyed deer hair serve as a fringe. While data are lacking, it is obviously an example of eastern Indian work, perhaps that of local Lenâpé.

Camp site, chips, fire-cracked stones, etc., occur at Prospertown. (28-34-1-4-4; 4-6; 7-3; 8-7; 9-3.)

A camp site, traces of wigwams and fireplaces, occur north of Prospertown. (28-33-3-9-6.)

Burksville.—Small camp site at Burksville, northeast of Prospertown. (28-34-2-1-4.)

Groveville.—A single grave and wigwam site were found on Major Woodward's farm above Groveville on Crosswicks Creek. (28-32-1-1-5.)

Bonaparte Park.—An Indian village once occupied the curved banks of Crosswicks Creek at Bonaparte Park opposite White Horse. Traces and relics are still common. (28-21-8-6, 9 and 9-7-1.)

Crosswicks Creek.—There was formerly an Indian ford across Crosswicks Creek where the trolley line to Bordentown now crosses. (28-21-8-6-8.)

White Horse.—Village site is located about the springs back of White Horse. (28-21-8-3-1.)

Trenton and Vicinity.

Abbott Farm.—Village site occurs on the Abbott Farm on a sandy knoll at the beginning of the lane. (28-21-8-2.)

Another village site, or series of sites, is intimately connected with the preceding, and is undoubtedly the best known of all Indian sites in New Jersey. The entire bluff from Abbott's Brook to the railroad track shows signs of prolonged Indian occupation, and from the fields Abbott and Volk have collected many specimens which are now in Princeton, Cambridge, New York, Chicago and elsewhere. Several burial grounds have been explored, and wigwam sites, caches and other remains have been exhumed.[1] (28-21-7-2-3 and 8-1.)

Somewhere in this neighborhood, the Lenâpé chief, Teedyuskung, the successor of Tammany, is said to have been born.

At the point on Abbott Brook, opposite the Abbott farm, Volk exhumed some skeletons from very deep graves. (28-21-8-1-9.)

On the slight sand ridge running out into the flat below the bluff Volk found a village site with scattered graves among the lodges. Many excellent specimens collected at this place are in the American and Peabody Museums. (28-21-8-1-8.)

Volk found a cache of chipped pieces in the outskirts of Broad Street Park. (28-21-8-1-5.)

Lalor Field, near Trenton.—The Lalor field, near Trenton, has long been a source of harvest for local collectors, and even to-day, after so many years of searching, specimens are still common after the first ploughing every spring. The writer has found a number of relics there which are now in the State Museum. The locality is undoubtedly one link in the continuous chain of village sites which occupies the sandy bluffs for some distance and marks the headquarters of the Unami division of the Lenni Lenâpé. At the particular spot designated on the map Volk found a single wigwam site surrounded by ten graves. This is on Sassafras Lane. Near here also he found a fragment of bison bone. (28-21-7-3-4.)

---

[1] The literature of this site is extensive, and the student is referred to the following works for a detailed knowledge of the field.

Abbott, C. C.—The Stone Age in New Jersey.
Primitive Industry.
Archæologia Nova Cæsarea.
Ten Years' Diggings in Lenâpé Land.
Volk, Ernest—Archæology of the Delaware Valley.

Deutzville.—Volk found fragments of human parietals and a femur in the gravel.[1] (28-21-7-2-1.)

Assanpink Creek.—There was formerly a large village site at the mouth of the Assanpink Creek in Trenton. Charles Rau has collected and figured articles from this locality. (28-21-4-4-4.)

Hancock Avenue.—Volk found here the fragments of musk-ox bone and elk antler, figured and described in his "Archæology of the Delaware Valley," p. 111. (28-21-3-8.)

Bile's Island.—On the shore of Delaware River nearly opposite the point of Bile's Island there was an historic Delaware Indian cemetery, now nearly obliterated. From this site were collected some interesting shell beads (wampum) and little bird-shaped shell pendants. Such objects are common enough in the old territory of the Iroquois but are practically unknown in New Jersey. Without doubt they show the influence of the Iroquois. These specimens are now in the collection of the Peabody Museum of Archæology and Ethnology at Cambridge, Mass. Dr. Abbott informed the writer that some modern Delaware Indians, from the west, visiting Trenton with Buffalo Bill some years ago, were in possession of so vivid a tradition of the location of this cemetery that they were able to find it, although none of them had ever seen the place before. On arriving at the spot they held a ceremony in memory of their dead. (28-21-7-5-1.)

There was an Indian village on the point of Bile's Island and many relics have been collected on the northeast shore of the island. (28-21-7-4-5.)

Moon's Island.—Volk has collected specimens all along the northeast and east bank of Moon's Island. There was probably an Indian village at this spot. (28-21-7-1.)

Titusville.—Remains are reported at Titusville. (27-14-4-8.)

Washington's Crossing.—Specimens have been collected at Washington's Crossing. (27-14-7-3-3.)

---

[1] See Ernest Volk, "Archæology of the Delaware Valley," p. 113, *et sec.*

Scudder's Falls.—Remains are reported from Scudder's Falls. (27-24-2-2-3.)

Princeton.—Abbott reports an argillite find on the Olden farm near Princeton. (28-12-1-7-8.)

Lambertville.—The presence of abundant Indian remains is reported all about Lambertville. The town probably occupies the site of a former village. (27-3-8-5, 8 and 9.)

Bulls Island and Raven Rock.—On Bulls Island and at Raven Rock many specimens have been found under conditions indicating prolonged Indian occupancy. Just opposite, on the Pennsylvania side at Point Pleasant, Mercer has made a series of investigations in the argillite quarries worked by the aborigines (27-2-5-6 and 6-7.)

List of Sites, with Notes, Northern New Jersey.

By MAX SCHRABISCH.

SITES IN THE DELAWARE VALLEY.

Delaware Water Gap.—A rock shelter was found at the western base of Blockade Mountain, within 100 yards of Delaware River. The finds made included some twenty or more arrow points and scrapers, one rude celt, unio shells, numberless bones, mostly deer, as well as large quantities of chips and potsherds, the latter, as usual, lying in the upper layers. The decoration of the potsherds was partly Iroquoian, partly Algonkin. One large fireplace and several bone pits were unearthed. (21-41-2-9-3.)

Camp sites and fishing places have been noted along the river in the Gap at several points (21-41-3-4-4; 7-4, 7; 7-5, 6). At another of these (21-41-3-4-1) a profusion of flakes, mostly flint, indicates a workshop.

A small shelter at the base of Blockade Mountain facing west and less than 100 yards from the river contained potsherds only, both plain and ornamented. It may, therefore, have been a so-called menstrual shelter, serving as a place of retirement for the women, in accordance with usages common among primitive peoples (21-41-3-7-4).

Below Delaware Water Gap as far as Columbia a series of camp sites has been identified on the east bank of the river. (Localities 21-41-6-2-4, 5; 2-7, 8; 5-2, 5; 5-6; 9-4; 9-4; 9-5; 9-8; 9-9.)

Manunka Chunk.—Two camp sites were found on a hill near a brook, 2 miles north of Manunka Chunk and 1 mile east of the Delaware; another site occurs half a mile south of these (24-2-5-9-2; 9-5).

Oxford Township.—There are camp sites and fishing places near Manunka Chunk (24-28-2-4; 4-5), a camp site south of Manunka Chunk (24-2-8-4-6), camp sites near Belvidere (24-

12-1-2-1; 5-4), and along Buckhorn Creek (24-12-4-2-2, 5; 2-3; 2-3, 6); a burial ground on top of Jenny Jump Mountain (24-2-9-6-1); a rock shelter 3 miles below Belvidere on the east bank of Delaware River (24-11-6-3-6).

There is also a village site in Hope Township on the southern shore of Green Pond, near the foot of Jenny Jump Mountain (24-3-7-4-3).

SITES IN THE WANAQUE VALLEY.

Stonetown.—There is a camp site 1 mile south of Stonetown and west of Winbeam Mountain. A large rock, hollowed out on top and evidently used as a mortar by the aborigines occurs on this site (23-31-1-6-7).

Upper Midvale.—Two small camp sites occur at Upper Midvale on elevated ground north of swamp (23-31-5-2-3).

Midvale.—Two camp sites occur near Midvale on the east bank of a tributary of Wanaque River (23-31-5-2-9; 5-8).

Pompton Junction.—A small Indian cave has been located high up on the southern slope of Federal Hill (23-31-7-9-7).

North of the Junction three camp sites were found between the railroad and a tributary of Wanaque River (23-31-8-4-7; 7-1), and another was found on the east bank of Pequannock River just south of the Junction (23-41-2-1-1).

SITES ON POMPTON PLAINS AND VICINITY.

Riverdale.—At Riverdale and vicinity five camp sites have been located (23-41-1-6-3; 6-5; 6-5; 6-6; 6-6).

Pompton Plains Station.—Three rock shelters occur on the eastern slope of the hills, 2 miles northwest of the station. Two of these (23-41-1-4-8; 4-9) are in a gully. The third (4-8) lies 150 yards south of the others. This shelter is the best of the three and its exploration yielded various remains of the Indian's handiwork, such as potsherds, scrapers, knives, drills, points and spearheads. A brook in front supplied its tenants with water and there is also a spring close by.

Southeast of these shelters five camp sites occur along a small brook and on the top and flanks of a wooded hill east

thereof, 1½ miles north by west of Pompton Plains station (23-41-1-8-1; 8-2; 8-4; 8-4, 7; 8-7). Scattered relics, probably lost while hunting occur in the fields toward the station (23-41-1-8-3; 9-1).

Five camp sites and fishing places have been located on and near the west bank of Pompton River north of Pompton Plains station (23-41-2-4-4; 4-5; 7-1; 7-5; 8-4).

A village site is found on elevated ground a short distance north of Pompton Plains station between the Erie Railroad and Pompton River (23-41-2-7-5, 6, 7, 8). A camp site is west of it (23-41-2-7-5), another east (23-41-2-8-7).

A large village site is found on Sander's lots, 1 mile west of Pompton Plains station. This locality has proved most prolific in specimens of aboriginal origin, and it is evident that it has been the site of a populous Indian village, occupied for many centuries. It does not appear to have been a temporary abiding place, abandoned every now and then, but seems to have been continuously occupied for long periods. On the other hand, we may assume that its population constantly shifted. Bands would leave it now for a while and others would come to take their places. Every kind of artifact characteristic of ancient village sites, has here been found, in contradistinction to mere camp sites or temporary fishing places, where certain kinds of implements are hardly ever met with (23-41-4-2-3, 6).

Another village site lies a short distance south of the former. Judging from the abundance of artifacts found here, we may conclude that this level and high tract of land was once occupied by an Indian settlement of no mean proportions. One thing is certain beyond peradventure and that is that Pompton Plains was one of the most frequented aboriginal sections in Northern Jersey, and there is good ground for assuming that these genuine Americans of the Lenni Lenâpé nation were in the habit of holding their powwows on these plains (23-41-4-3-4, 7).

South of Pompton Plains station no less than nine sites have been identified, one of them a village site and fishing place (23-41-5-2-8). Their exact locations are as follows: (23-41-5-1-2; 1-5; 1-6; 1-3, 6; 2-2; 2-4; 2-7; 5-1). Scattered relics were also found (23-41-5-2-2; 5-5).

Pompton.—Eleven aboriginal sites have been noted in and about Pompton, Wayne Township, Passaic County. The most important of these is a village site on elevated ground east of Pompton River and south of the junction of Pequannock with Ramapo River (23-41-2-4-5, 6, 7, 8). Of the remaining ten sites two lie on the east bank of Wanaque River (23-41-2-1-9; 4-3), the others are distributed along the east bank of Ramapo River and some of its tributaries. Two of these sites lie respectively north and south of point where Peacock Brook empties into Pompton Lake (23-41-2-3-4; 3-7). The exact location of the others is as follows: (23-41-2-5-3; 5-6, 9; 5-9; 9-1; 9-4; 9-5). Scattered relics were found both on the west bank of Peacock Brook and on the east bank of Ramapo River (23-41-2-3-9; 8-2, 3; 8-3).

Jacksonville.—Numerous traces of erstwhile Indian occupation have been found in and near Jacksonville, 2 miles southwest of Pompton Plains. Altogether eleven camp sites have been located on the ridges bounding Bog and Vly swamp on the west. (23-41-4-1-5; 1-5, 6; 1-7; 2-1; 2-2; 2-4; 4-3; 4-6; 4-8, 9; 5-1; 7-1, 3.)

Pequannock.—A village site and fishing place lay on the west bank of Pompton River about 500 yards east of Pequannock station. The flood of October, 1903, overflowing the banks of the river and tearing up the soil, laid bare numerous prehistoric artifacts, among them fragments of pottery. The ornamentation, particularly the incised line pattern, is identical with that found on the village site at Pompton Plains. This is not surprising if we reflect that those who designed it were members of the tribe roaming over the Pompton Plains, viz., the Opings or Wapings. There was an old tradition that this clan formerly lived on the shores of Long Island, migrating thence westward in the sixteenth century. (23-41-5-5-8, 9.)

Another village site lay a short distance south of the former. These fields, once known as the "Indian Orchard," have also been very prolific in aboriginal specimens. A much-trodden trail connected this place with the Indian villages at Wayne and Pompton Plains, following in part the course of the river. (23-41-5-8-2, 5.)

Almost opposite these villages two camp sites have been noted on the east bank of Pompton River, Wayne Township, Passaic County (23-41-5-8-9; 9-1, 4).

In addition to these, five more sites have been located some distance west of the river between the Erie Railroad and the Bog and Vly. Two lie a short distance east of the Bog and Vly about 1½ miles from the station (23-41-4-6-5; 6-5, 8); the remaining three, one of them a village, occupy the elevated ground bounding a large swamp north and west (23-41-4-9-3, 6. 9; 5-4-6; 4-8).

Wayne.—Two camp sites occur north of Wayne, two more on the bluffs east of it and another farther south near the powder works, all of them east of Pompton River (26-1-2-2-2, 3; 2-3; 3-2; 3-6; 6-1).

Mountain View.—Two village sites occur here in the southernmost part of the Pompton Valley, one of them west of Pompton River at the southeastern extremity of Towaco Mountain, the other east of Pompton River, between Mountain View and Two Bridges (26-1-2-6, 9-7, 8, 1, 2; 3-7-4, 5, 7, 8).

Lincoln Park—The country about Lincoln Park reveals many traces of aboriginal occupation and no less than seven sites including two villages have been identified. It is watered by several brooks and topographically is well defined, being bounded to the west by Bog and Vly swamp, south by Towaco (Hook) Mountain and east by Pompton River. The light sandy soil covering the fields has yielded numerous implements of primitive art and scattered relics occur all over this region. One village lay north of the D. L. & W. Railroad in the angle formed by it and Pompton River, the other south thereof between the railroad and Towaco Mountain, a patch of swampy ground separating the two sites. (26-1-2-1, 4-8, 9, 2, 3; 4-1,2.) Four of the camp sites were distributed along the north bank of a tributary of Pompton River, the fifth one occupied a bluff near the railroad bridge. (26-1-1-3-5, 6; 2-1-7; 1-5; 1-6; 5-1.)

TOWACO SITES.

West of Lincoln Park a number of sites have been located in the undulating country known as Towaco. Two of these lie at

the southern base of Turkey Mountain, two others a short distance north of Towaco station and the two last between Towaco and Lincoln Park on the southern edge of Bog and Vly swamp. (25-5-1-1-5; 1-6; 2-8; 2-9; 26-1-1-1-4; 1-5.)

SITES IN THE NORTHERN HIGHLANDS.

Morris County.

Jefferson Township.—A camp site and fishing place occurs on Raccoon Island, and a village site and fishing place on Halsey Island, both at Lake Hopatcong (22-42-4-3-5; 3, 6-9, 3).

A camp site was found half a mile south of Milton and another half a mile east of Milton on the banks of Rockaway River (22-33-8-4-9; 5-2).

Rockaway Township.—A camp site and fishing place has been located at the southern end of Splitrock Pond. (22-44-4-1-4.)

Montville Township.—A rock shelter, called Bear Rock, occurs near Brook Valley, 4 miles north of Towaco. It lies in a valley formed by Stony Brook Mountain and Rock Peon mountain and is unique for the reason that it hangs over on two opposite sides, the result being a double rock shelter, facing east and west, respectively. The rock itself is a granite boulder of enormous size, deposited here during one of the glacial periods. While the excavation yielded many implements of aboriginal handiwork, pottery was not plentiful. It lay, as in all the other shelters thus far explored by the writer, either on the top of the débris or a little below, but nowhere near the bottom. From this we may infer, as heretofore, the existence of two distinct horizons of culture. (22-44-6-1-9.)

Passaic County.

West Milford Township.—This region, like all the land north and west of it, is a mountainous territory, known as the Jersey Highlands. Owing to its inaccessibility it was merely a hunting resort, traveled over occasionally, with no permanent village sites and but a few lodge sites and rock shelters denoting the

Redman's former presence. An interesting place of this kind is a rock shelter situated at the eastern base of Kanouse Mountain about a quarter of a mile north of Macopin (Echo) Lake. It faces east and some 50 yards from it a brook flows past into the lake. The dirt covering the floor contained only a few arrow points, but there was a profusion of potsherds, showing Algonkin designs, some flakes and indications of two fireplaces. (22-34-2-9-4.)

Bergen County.

Hohokus Township.—A few sites have been discovered in the interior of the Ramapo Mountains, and we may assume that the aborigines occupied them only when on hunting trips. At all other times land of this character was, as a rule, not invaded by human beings.

A camp site lies on the western bank of Bear Swamp; a second camp site and workshop occurs south of it at the lower end of Bear Swamp. (23-32-1-2-1; 2-4.)

A small rock dwelling has been found 1 mile east of Bear Swamp and about 3 miles northwest of Darlington. It occupies a gully in one of the most inaccessible portions of the Ramapo Mountains and it contained but few traces of Indian origin, among them being chips, fire-cracked pebbles and some rejects. (23-32-1-3-8.)

Franklin Township.—Another rock shelter has been located in the southwestern part of the Ramapo Mountains, 3 miles north of Oakland. The scarcity of relics imbedded in the soil under the rock proves that this spot was but seldom visited by the red huntsman. For this several reasons may be adduced. In the first place, the shelter was quite inaccessible, lying almost on top of a hill, some 800 feet above sea level. Secondly, the condition of the surrounding country shows that water may not always have been available, for, although there is in its immediate vicinity a small swamp, it is altogether probable that it dried up during periods of drouth. Apart from this however, the configuration of the shelter is such as to have met with the requirements of any roving redskin. (23-31-6-6-5.)

SITES IN THE RAMAPO VALLEY.

Hohokus Township.—A village site has been identified on the south side of Ramapo River, 1 mile north of Darlington (23-32-2-5-3).

Franklin Township.—Two camp sites occur within a distance of 4 miles on the north bank of Ramapo River (23-32-4-4-5; 31-9-4-3).

Wayne Township.—Two neighboring camp sites have been found on the flats between the N. Y. S. & W. Railroad and Pompton Lake (23-31-8-9-1; 9-2).

SITES IN THE PASSAIC VALLEY.

Pine Brook.—There are three camp sites south of Pine Brook on the west bank of Rockaway River, a tributary of Passaic River. (25-5-7-5-9; 5-2; 5-3.)

Another camp site occurs half a mile east of Pine Brook on the west side of a swamp near Passaic River. (26-1-7-1-7.)

Horse Neck Bridge.—There is a camp site on the west bank of Passaic River, between Horse Neck Bridge and Towaco. (25-5-1-9-8.)

Tom's Point.—In the angle of Towaco (Hook) Mountain two rock shelters have been located. At the westerly one investigation disclosed two fireplaces filled with charcoal, chips, potsherds and bones. In addition, the culture layers yielded several arrow points, scrapers, one pitted hand hammer, knives and a broken steatite bead. The bones were mostly those of deer, but among them there were also the jawbone of a raccoon and a couple of oyster shells. Most of the pottery was plain; the ornamented pieces were either cord-marked or incised, the zigzag design predominating. (26-1-1-4-1.)

The easterly shelter yielded still fewer relics. However, there was among them a gorget perforated on both ends. (26-1-1-4-3.)

Tom's Point proper was once occupied by a village of large size. Both the variety and number of specimens occurring in this locality give evidence that the aborigines have lived here in

considerable numbers. Its sheltered position in the bend of Towaco Mountain made it eligible as winter quarters, and the nearness of Passaic River permitted its occupants to supplement their meat fare by many kinds of fish with which this river was then well-stocked (26-1-1-4, 5-6, 2, 9, 7). All of the sites in the Passaic Valley thus far mentioned are in Morris County.

Franklin.—A camp site occurs on the north bank of Pine Brook between Hatfield Swamp and Franklin. (26-1-7-6-4.)

Pine Brook Bridge.—There is a camp site between Long Meadow and Passaic River (26-1-7-2-9).

Clinton.—Half a dozen camp sites occur in the vicinity of Clinton between Great Piece Meadows and Long Meadow (26-1-4-8-6; 6-5; 6-6; 9-3; 5-4-1; 5-7-2).

Fairfield.—Archæologically speaking, the Fairfield section is one of the best in the Passaic Valley for several reasons. In the first place, it is well sheltered, Towaco Mountain enclosing it north and west, and the North Caldwell Hills on the southeast. Secondly, Passaic River, then teeming with fish, envelops it on three sides; and, thirdly, it is a level tract of land, pitted by swamps, with many knolls composed of light sand rising above the low-lying meadows. Each of these knolls reveals to this day the traces of ancient occupation in the shape of aboriginal utensils littering the soil. Altogether, eleven sites, one of them a village, have been located within this territory. The village lay on land owned by David Demarest, on the southern bank of Passaic River, south of Two Bridges and opposite the confluence of Passaic and Pompton rivers. Innumerable objects of primitive art have here been recovered of late years. In front of the village a ford or fish weir crosses Passaic River a little below the county bridge (26-1-5-3-3, 4, 5, 7, 8). The camp sites have been located as follows: (26-1-5-9-4; 9-1, 2; 9-1; 8-3; 5-9; 6-6; 5-2; 2-9; 2-9; 2-6). The position of the ford is: (26-1-5-3-2). All the sites in the Passaic Valley mentioned under the side heads of Franklin, Pine Brook Bridge, Clinton and Fairfield are in Essex County.

Singac.—There is a group of sites in the vicinity of Singac, three being on the south side of Passaic River and four north

of it, the latter lying between Singac Brook, a tributary of Passaic River, and the Greenwood Lake branch of the Erie Railroad. (26-1-6-5-5; 5-5, 6; 6-1); (26-1-6-1-6; 4-5, 6; 2-7; 5-1.)

Little Falls—Five sites have been noted near Little Falls, three of them south of Passaic River, two north of it. Of the former, one lies north of Cedar Grove, on the east bank of Peckman's Brook, a tributary of Passaic River, the next one about 1½ miles farther north, also on the east bank, and the third one near its mouth. (26-2-4-7-9; 5-3; 2-8, 9.) The northerly ones lie close together on the bank of the river, about opposite the mouth of Peckman's Brook (26-2-4-2-5; 2-5, 6). There are, moreover, three fords across the river, two above High Bridge, one below it, running from its south bank to Laurel Grove Island (26-2-4-3-4; 3-6; 3-3).

City of Paterson.—There is no doubt that the territory now occupied by the City of Paterson was once a favorite resort of the Indian, and this assumption is amply borne out by the traces of prehistoric activity discernible to this day. Again, it is certain that in the course of building operations many sites, including even rock shelters, have forever been obliterated. Still, wherever the natural conditions of the land have not been disturbed, many sites can, even now, easily be identified. Most of these occur, obviously enough, along the banks of the river, but more particularly on the extreme east side of the city, where there are few houses. In the following we shall enumerate all sites occurring directly within the city limits and then proceed to mention those lying just outside of them in the vicinity of the river.

Four sites have been found on the west side of the city, called Totowa, on the flats extending north of the river to the foot of Totowa Hill. (26-2-2-4-7; 4-9; 1-5, 8; 1-8.)

There was a site at the Falls, another on Paterson Island and a ford crossed the river below Main Street Bridge (26-2-2-5-6; 6-1; 6-2.).

Along the northernmost course of the river there occur the following: a camp on Bunker Hill, a ford north of it, two

fords between Wagaraw and Fifth Avenue Bridges (23-42-6-7-8; 7-8; 9-4; 9-7, 8).

There are twelve camp sites and one ford between Broadway and Wesel Bridges along the west bank of the river (26-2-3-3-1; 3-1; 3-4, (ford); 2-6; 3-7; 6-2; 6-3; 3-1-4-1; 2-3-6-6; 6-9; 9-6; 9-6, 9; 9-8, 9). All the sites given under the side heads of Singac, Little Falls and Paterson are in Passaic County.

A few more sites, also in Passaic County, occur north of Passaic River, as follows:

Ashley Heights.—A camp site and workshop near a swamp at the southern extremity of Goffle Hill (23-42-5-9-2).

Hawthorne.—Two camp sites occur near the mouth of Goffle Brook, four more to the eastward, between Goffle and Wagaraw Brooks (23-42-6-7-4, 7; 7-5); (7-2; 7-3; 7-6; 8-4).

North Paterson.—There are two camp sites on the east bank of Goffle Brook, about 1½ miles north of Passaic River (23-42-6-4-2; 1-8).

Van Winkle.—A site occurs at the forks of Deep Glen and Goffle Brooks, opposite the schoolhouse (23-42-6-1-2, 3).

Bergen County, *i. e.*, that part of it which lies east of Passaic River, is replete with the signs of ancient occupation. But while it is quite certain that there is not a single square mile in this territory entirely devoid of such signs, it is, nevertheless, certain that the region adjoining the river ranks first in point of aboriginal traces, and here again it is that part of it which lies opposite the City of Paterson, viz., just beyond its boundaries.

Some fifty sites have been noted on the level strip of land lying between the river and the Bergen County short cut of the Erie Railroad and extending 8 miles downstream from Fairlawn to Garfield. While most of the sites occur in close proximity to the river, others are some distance away. The former were, no doubt, more desirable than the latter, as fishing places, and therefore resorted to more or less permanently.

Ferndale.—Five sites have here been located, all within 1½ miles north of the great bend of Passaic River. Three of these are west, two east of Wagaraw Brook (23-42-6-3-8; 6-1; 6-4, 7); (6-6, 8; 6-8, 9).

Fairlawn.—A village site lies west of Wagaraw Brook near its mouth (23-42-6-5, 6, 8, 9-9, 7, 3, 1). Two more villages have been identified east of Wagaraw Brook, and there was a workshop on the bluff parallel to the river, between Wagaraw and Fifth avenue bridges (23-42-6-9-2, 3; 9-3, 6; 9-8). Four camp sites occur along a brook, 1½ miles east of the river, and scattered relics are found on both sides of the railroad. (23-42-6-9-3; 43-4-4-7; 4-7, 8; 4-8; 7-1; 7-2; 4-9; 5-4.) An isolated site has been noted one-half a mile east of Fairlawn, near a brook, a westerly tributary of Saddle River (23-43-4-8-9).

Bellair.—Twelve camp sites, mostly fishing places, and one village site have been noted along the bank of the river between Fifth avenue and Broadway bridges (26-2-3-3-4, 5; 3-4, 5; 3-5; 3-6; 3-6; 3-7, 8; 3-9; 3-1-1-7; 1-7; 1-7, 8; 1-8; 1-8; 4-2, 5).

Warren Point.—There are two camp sites at Warren Point on a brook north of the station (26-3-1-2-8; 5-2).

Passaic Junction.—Two sites have been found north of Passaic Junction, east and west of the railroad (26-3-1-8-5; 9-8).

Dundee Lake.—Many sites have been located north and south of Dundee Lake, all but one on the bank of the river (26-3-1-7-1; 7-4, 5; 7-7; 4-1-2; 1-5; 1-8; 1-8; 4-2; 2-1, 2).

Dundee Dam.—There is a fishing place both above and below Dundee Dam. (26-3-4-4-5; 5-4.) A ford crosses the river between the two. (26-3-4-4-6.)

Plauderville.—A site occurs northwest of Plauderville, about two-thirds of a mile from the river. (26-3-4-5-3.)

Belmont.—There is a ford crossing from the east bank of Passaic River to the island, opposite Belmont. (26-3-4-8-2.)

Garfield.—A site has been found south of Garfield, at the mouth of Saddle River. (26-3-7-3-5.)

Carlton Hill.—There is a site near the railroad bridge, opposite Passaic Park (Passaic Bridge). (26-3-7-5-7.)

The remaining sites in the Passaic Valley are on the west side of the river south of Paterson.

Lake View.—Three sites have here been located, one of these on the bank of the river near the Paterson boundary line, the others south of it, on opposite sides of a brook, some 300 yards

from the river (Godefroy's estate). (26-3-4-1-4, 7; 2-6-6-2; 6-3.)

Clifton.—A site occurs above Dundee Dam, near the mouth of a brook. (26-3-4-4-4.)

City of Passaic.—Most all the signs of aboriginal occupation have long ago been effaced hereabouts. It is known, however, that two Indian villages were situated within the city limits, one of these on the peninsula in the eastern section of the city, the other 1 mile to the west of it in the vicinity of Prospect Street station. (26-3-7-1-6, 9; 3-4, 7.)

Nutley.—While the sites mentioned under the last three side heads are in Passaic County, there is one occurring just across the county line near the mouth of Yantecaw or Third River, at Nutley, in Essex County. (26-12-3-6-3.)

It is worthy of note that sites occur most frequently at the Great Bend or northernmost point of the river, where it changes its northeasterly course into a southerly one, and that south of Paterson they decrease in number, with the exception of a stretch of land south of Dundee Dam, on the east bank of the river. Again, no sites have been found in the undulating country extending westward from Passaic River to Garret Mountain, and this may seem the more surprising as it is watered by several brooks, all flowing into Passaic River.

SITES ON GARRET MOUNTAIN.

City of Paterson.—Three rock shelters have been located at the northern extremity of Garret Mountain, one of these is at the foot of Garret Rock, the others on the eastern slope of the mountain, on Catholina Lambert's estate, South Paterson. (26-2-2-9-4; 5-3-2; 3-2.)

Little Falls Township.—Scattered relics have been found in two places, and a camp site occurs a half mile west of Albion Place, all on top of the mountain. (26-2-5-3-1; 2-6; 2-6.)

Acquackanonk Township.—There is a camp site at the foot of the mountain on the west bank of Yantecaw or Third River, near Great Notch, 3 miles south of Paterson. (26-2-5-7-9.)

OTHER SITES BETWEEN POMPTON-RAMAPO RIVER AND SADDLE RIVER.

Haledon.—A site has been noted west of a brook, on Haledon Hill. (23-42-5-7-2.)

North Haledon.—Two sites have been found on Haledon Hill, one of these at the head of a small brook, the other, a workshop, half a mile north of it, on the west bank of High Mountain Brook. A site occurs at the intersection of High Mountain Brook and the Haledon turnpike. Three other sites and scattered relics have been noted east of Squaw Brook. (23-42-5-4-8; 4-2, 5; 5-4; 2-6; 2-8-7; 7-6; 7-3, 6.)

Lower Preakness.—This locality was much favored by the Redman by reason of its advantageous position. It is in a valley sheltered on the northwest by Packanack Mountain and on the southeast by Totowa Hill. Water is supplied by Singac Brook and its tributaries, and the fields bordering them are level and dry and covered with light alluvial soil. Half a dozen aboriginal sites have here been identified, five of them on the south side of Singac Brook, the other one north of it. (26-1-3-3-8, 9; 6-7; 6-9; 6-6; 2-1-4-5; 4-3.)

Upper Preakness.—An isolated camp site occurs in the valley west of Packanack Mountain, half way between Upper Preakness and Wayne. (26-1-3-1-3.) Half a dozen skirt Singac Brook and its affluents south of what was once known as Barbour's Mills (Hinchman and Hausamann farms, &c.). (23-41-6-6-4; 6-3, 6; 42-4-4-4; 4-4-6; 4-9; 5-2.) Three sites occur in Preakness Mountains, one of them on the southern slope on High Mountain, two others east and southwest of Beech Mountain, and scattered relics lost during the chase have been picked up in several places hereabouts. (23-42-4-3-3; 1-8-6, 9; 4-1-3; 3-6; 1-8-4.) Five more sites have been noted on opposite sides of a swamp (headwaters of Peacock Brook) north of Point View. (23-41-3-8-1; 8-4, 7; 8-3; 8-6; 8-8, 9.)

South of Franklin Lake.—A most interesting district lies south of Franklin Lake, for it is here that three rock shelters occur, each showing the earmarks of ancient occupation. The principal one is situated at the southern

end of the Clove, a narrow ravine extending northward in the direction of Franklin Lake, 1 mile distant. That this ravine was the site of a much-trodden trail may be inferred from the evidence extant. Though one of the poorest of shelters as to size and configuration, it proved one of the best with respect to aboriginal remains. The evidence suggests a few general conclusions relative to its character. In the first place, we may take for granted that it was often tenanted, not only by single hunters, but also by whole families. Second, such occupation would be more or less permanent, and all this we may confidently assume both because of its favorable location and the thickness of the culture layers accumulated under its roof. Furthermore, the relic-bearing strata reveal two distinct horizons of culture, as indicated by the presence of potsherds in the upper layers and their complete absence in the lower ones. (23-42-1-7-2.)

The next shelter lies also in the Clove, a short distance north of the former, and it contained nothing but fragments of pottery in great abundance. (23-42-1-7-2.)

The third one occurs in a neighboring gully, which runs west of and parallel to the Clove, on Thomas Fleming's farm (23-42-1-7-1).

In addition, there is a camp site at the northern end of the Clove, half a mile south of Franklin Lake (23-42-1-4-8), and another near the southern entrance to it, between the forks of Singac Brook, on Thomas Fleming's farm (23-42-1-7-4).

Scattered relics occur on the fields west of the Clove (23-41-3-9-2).

Franklin Lake.—There are three sites on the western and one on the eastern shore of the lake, just across the county boundaries (23-42-1-4-2; 4-2, 5; 4-6; 2, 5-8, 2). A fifth one lies south of a swamp, near a brook, some 400 yards east of the lake (23-42-1-5-3). Moreover, an aboriginal burial ground is said to be situated two-thirds of a mile northeast of the lake, a short distance north of the Sicomac road (23-42-2-2, 3-6, 4).

The Indians, in their flowery language, called this sheet of water "Crystal Eye," on account of its pellucidness, and they often came here to fish; hence, the camp sites dotting its shores.

Blauvelt Lakes.—An ancient village occupied the level tract of land extending northwest of Franklin Lake. There is also a camp site east of Blauvelt Lakes, and about half a mile north of Franklin Lake. (23-41-3-3-6; 42-1-1-2.)

Sicomac.—In the section of country, known as Sicomac and lying between Franklin Lake and Midland Park, two camp sites and one burial ground have been located. The former are on the banks of Squaw Brook, not far from its headwaters, 1½ miles east of the lake; the latter is on the old Van Blarcom farm, 2 miles west of Midland Park (23-42-1-6-6; 2-4-4; 6-4, 5).

Midland Park.—Scattered relics have been found east of Deep Glen Brook, 1 mile southwest of Midland Park (23-42-3-4-9; 7-3).

Wyckoff.—There is a camp site on the bank of a small brook, west of the railway station (23-32-8-6-7).

Ramsey.—A site has been noted on a knoll south of a swamp, ¾ miles south of Ramsey, and east of the Erie Railroad tracks (23-32-6-6-5, 6).

SITES IN THE SADDLE RIVER VALLEY.

If the comparative scarcity of sites may be accepted as a safe criterion, there can be no doubt that the territory through which Saddle River flows was to the Indian of secondary importance to the Passaic Valley. Saddle River being but a tributary of Passaic River, the aborigine was, naturally enough, attracted to the larger water course, a few miles to the westward, with its superior opportunities for fishing and hunting.

Thus far only eighteen sites have been ascertained within the region watered by Saddle River, a few of them occurring along the banks of its two principal affluents, namely, Hohokus Creek to the west, and Sprout Brook to the east.

Town of Saddle River.—Two camp sites and one rock shelter have been found on the east bank of the river, about 1 mile south of the town of Saddle River. The rock shelter lies some 300 yards east of the river on the western slope of a ridge, which runs parallel to the river, on Mrs. Isabel Miller's estate. Investigation disclosed a fireplace, containing charcoal and fire-stained

pebbles and in the soil covering its floor there were found some fragments of pottery, chips, bones and a few arrow points of inferior workmanship. (23-33-7-6-6; 8-4-7; 8-4-5.)

Paramus.—On the plains of Paramus, 3 miles downstream, there are three sites near the river, one of them west, the other two east of it (23-43-2-7-1; 7-6; 7-9). Two sites have been noted southeast of Paramus, at the headwaters of Sprout Brook (23-43-5-2-5; 3-1).

Ridgewood.—East of this town there occur two sites on the east bank of Hohokus Creek (23-43-1-6-4; 6-8).

Dunker Hook.—There are three sites at a place called Dunker Hook, 2 miles south of Paramus, two of them west, the other east of Saddle River (23-43-4-6-5, 6; 5-7-1, 2; 5-4-4).

Arcola.—A number of sites have been identified in the neighborhood of Arcola, 2 miles east of Passaic River. Three of these ancient camps were distributed along the western bank of Saddle River, the fourth and most southerly one lay east of it. (26-3-2-1-1, 2; 1-4; 1-8; 5-4.)

An exceptionally good site, probably a village, if one may judge by the profusion of artifacts recovered here in years gone by, occupied the elevated ground east of Sprout Brook, a short distance north of its confluence with Saddle River, between Arcola and Rochelle Park (26-3-2-8-2, 3).

SITES IN THE HACKENSACK VALLEY.

Few data have as yet been obtained concerning the location of aboriginal sites in the region watered by Hackensack River and its affluents. Best known thus far is a section of country lying about 3 miles west of Hackensack River in the townships of Hillsdale and Washington. Six sites have here been noted on or near the banks of Musquapsink Creek, which flows into Pascack Brook, a westerly tributary of Hackensack River.

Wearimus.—The northernmost site is at Wearimus, 1 mile west of Hillsdale (23-33-9-7-4).

Westwood.—Four others lie close together, 1½ miles west of Westwood (23-43-3-4-2; 4-4; 4-5; 4-9).

Emerson.—The southernmost and last site occurs 1½ miles west of Emerson (23-43-3-8-7).

Spring Valley.—A group of four sites has been located on the banks of a brook which flows through Spring Valley, Midland Township, 1 mile west of Hackensack River. The two westerly ones are on the Stagg and D. H. Hopper farms. (26-3-3-1-6; 1-9; 2-4; 2-8.)

One site each occurs near *New Milford, New Bridge* and *Bogota,* all on the east bank of Hackensack River (23-44-4-7-6; 26-4-4-1-2; 4-4).

Teaneck.—There are two large sites on the elevated tract of land west of Overpeck Creek, an easterly tributary of Hackensack River (26-4-4-6, 9-9, 3; 9-6).

Highwood.—A site occurs on the east bank of a brook, 1 mile west of Highwood station, Northern R. R. of N. J. (26-4-2-8-5).

Additional Information Wanted.

Inasmuch as the foregoing list of sites is necessarily incomplete, the Survey is anxious to obtain any further information possible with especial reference to sites and their location. We would be very glad to hear from anyone interested in the subject, and suggest that information be sent to the following address:

STATE GEOLOGIST,
Trenton, New Jersey.

The particular data which we desire to secure are the following:

1. The exact location of any sites in your neighborhood which have been omitted or misplaced on the map.

2. The type of site, whether camp, village, cache, rock shelter, shell heap or cemetery.

3. Abundance and nature of relics found there.

4. Do you know of any old New Jersey Indian relics of a more perishable nature than those found in the ground or on the surface in the possession of any person? We refer to wampum, garments, wooden bowls, wooden mortars and the like.

5. Are there any living descendants of the old New Jersey Indians in your locality, or are any traditions of them still preserved?

6. The names of persons having collections of Indian relics. Donations of these to the State, through the Geological Survey, are invited.

BIBLIOGRAPHY.

ABBOTT, C. C. The Stone Age in New Jersey. (Smithsonian Report for 1875, Washington, 1877.)

Primitive Industry; or Illustrations of the Handiwork in Stone, Bone and Clay of the Native Races of the Northern Atlantic Seaboard of America, Salem, 1881.

Second Report on the Paleolithic Implements from the Glacial Drift in the Valley of the Delaware River, near Trenton, New Jersey. Salem, 1878.

Eleventh Annual Report, Peabody Museum of American Archæology and Ethnology. Cambridge, 1878.

Archæologia Nova Cæsarea. Trenton, 1907–1909.

Ten Years' Diggings in Lenâpé Land. Trenton.

ADAMS, R. C. Legends of the Delaware Indians and Picture Writing. Washington, 1905.

ANTHONY, A. S., AND BRINTON, D. G. A Lenâpé-English Dictionary. Philadelphia, 1888.

ATKINSON, JOSEPH. History of Newark, New Jersey. Newark, 1878.

BRAINERD, DAVID. Memoirs of Rev. David Brainerd, based on the life of Brainerd, prepared by Jonathan Edwards, D.D. New York, 1891.

BRINTON, D. G. The Lenâpé and their Legends; with a complete text and symbols of the Walam Olum. Philadelphia, 1885.

COLDEN, CADWALLADER. The History of the Five Indian Nations of Canada, which are the Barrier between the English and French in that part of the world, with particular accounts of their religion, manners, customs, laws and government, etc. London, 1747.

DANKERS, JASPER, AND SLUYTER, PETER. Journal of a Voyage to New York, etc., in 1679–80. (Memoirs of the Long Island Historical Society, Vol. 1, 1875.)

DENTON, DANIEL. Brief Description of New York, etc., 1670–1845. (William Gowans Bibliotheca Americana.)

DE VRIES, DAVID PETERSON. Voyages from Holland to America. New York, 1853.

HARRINGTON, M. R. Some Customs of the Delaware Indians. (Museum Journal, University of Pennsylvania, Vol. 1, Philadelphia, December, 1910.)

Vestiges of Material Culture among the Canadian Delawares. (American Anthropologist, Vol. 10, pp. 408–418. Lancaster, 1908.)

The Rock-Shelters of Armonk, New York. (Anthropological Papers, American Museum of Natural History, Vol. 3, pp. 125–138. New York, 1909.)

HARVEY, HENRY. History of the Shawnee Indians from the year 1681 to 1859, inclusive. Cincinnati, 1855.

HAYNES, HENRY W. The Argillite Implements Found in the Gravels of the Delaware River, at Trenton, New Jersey, compared with the Paleolithic Implements of Europe. 1881.

HECKEWELDER, REV. JOHN. An account of the History, Manners and Customs of the Indian Nations who once Inhabited Pennsylvania and the neighboring States. (Transactions of the Historical and Literary Committee of the American Philosophical Society, Vol. 1. Philadelphia, 1819.) Words, Phrases and Short Dialogues in the Language of the Lenni Lenâpé or Delaware Indians. (Transactions of the American Philosophical Society. Philadelphia, 1819.) Comparative Vocabulary of Algonkin Dialects. Cambridge, Mass., 1887.

HOLM, THOMAS CAMPANIUS. A Short Description of the Province of New Sweden, etc. (Memoirs, Historical Society of Pennsylvania, Vol. 3, part 1. Philadelphia, 1834.)

HOLMES, W. H. Are there Traces of Man in the Trenton Gravels? (Journal of Geology, Chicago.)

HRDLICKA, ALES. Skeletal Remains Suggesting or Attributed to Early Man in North America. (Bulletin 33, Bureau of American Ethnology, Washington, 1907.)

The Crania of Trenton. (Bulletin, American Museum of Natural History, Vol. 16, article 3, pp. 34–40. New York, 1902.)

LEE, FRANCIS B. New Jersey as a Colony and as a State. Chapters I and II. New York, 1902.

LOSKIEL, GEORGE HENRY. History of the Mission of the United Brethren among the Indians of North America. London, 1794.

MERCER, C. A New Investigation of Man's Antiquity at Trenton. (Proceedings of the American Association for the Advancement of Science, Vol. 46, 1897, with appendix by Arthur Hollick.)

MONTANUS, ARNOLDUS. Description of New Netherland. Amsterdam, 1671.

NELSON, WILLIAM.. The Indians of New Jersey. Paterson, 1894.

Personal Names of the Indians of New Jersey. Paterson, 1904.

The Salem Interpreter, recorded in office of the Secretary of State, Trenton, and printed by Nelson. (See The Indians of New Jersey.)

PLANTAGENET. New Albion, 1648.

RAU, CHARLES. Artificial Shell Deposits in New Jersey. (Annual Report, Smithsonian Institution, 1864.)

RUTTENBER, E. M. History of the Indian Tribes of Hudson's River; their origin, manners and customs, tribal and sub-tribal organization, wars, treaties, etc. Albany, 1872.

SCHRABISCH, MAX. Indian Rock-Shelters in Northern New Jersey and Southern New York. (Anthropological Papers, American Museum of Natural History, Vol. 3, pp. 141–165, New York, 1909.)

SKINNER, ALANSON. The Lenâpé Indians of Staten Island. (Anthropological papers, American Museum of Natural History, Vol. 3, pp. 3–62, New York, 1909.)

The Archæology of Manhattan Island. (Anthropological Papers, American Museum of Natural History, Vol. 3, pp. 113–121, New York, 1909.)

Archæology of the New York Coastal Algonkin. (Anthropological Papers, American Museum of Natural History, Vol. 3, pp. 213–235, New York, 1909.)

The Indians of Manhattan Island and Vicinity. (Guide Leaflet, No. 29, American Museum of Natural History, New York, 1909.)

SHARP, WILLIAM. (Ed. Smith's) History of New Jersey. Trenton, 1877.

THOMAS, GABRIEL. Historical and Geographical Account of Pennsylvania and West New Jersey in America. London, 1879 (1698).

VOLK, ERNEST. Archæology of the Delaware Valley. (Papers of the Peabody Museum of Archæology and Ethnology. Vol. 5. Cambridge, Mass., 1911.)

WOLLEY, CHARLES. A Two Years' Journal in New York, etc. London, 1701. (Reprinted, New York, 1860.)

WHITEHEAD, WILLIAM A. The Model of the Government of the Province of East New Jersey in America. Edinburg, 1685.

ZEISBERGER, DAVID. Diary of David Zeisberger, a Moravian Missionary among the Indians of Ohio. Translated and edited by E. F. Blin, Cincinnati, 1885. 2 vols.

Indian Dictionary, Cambridge, Mass., 1887.

Grammar of the Language of the Lenni Lenâpé or Delaware Indians. Translated by P. S. Duponceau. (Transactions of the American Philosophical Society, Vol. 3, Philadelphia, 1830.)

CONTRIBUTORS.

We wish to acknowledge our indebtedness to the following persons, all of whom gave important information and courteous assistance:

T. Burrows, 517 Grant St., Camden, N. J.
Joseph R. Simonds, Aylesford Farm, Indian Hill, Toms River, N. J.
Dr. Edward Sharp, Salem, N. J.
Frank D. Andrews, Vineland, N. J.
Wm. S. Hurff, R. F. D. No. 5, Sewell, N. J.
Hon. John S. Applegate, Red Bank, N. J.
Geo. Wm. Bassett, Hammonton, N. J.
Frank D. Andrews, Vineland, N. J.
Fred Summerill, Pennsgrove, N. J.
C. L. Duvale, Leonards, N. J.
John Hall, 1311 Pacific Ave., Atlantic City.
Silas R. Morse, 26 South Carolina Ave., Atlantic City.
A. Robert Gordon, P. O. Box 129, South Amboy, N. J.
George McAltioner, Woodstown, N. J.
Rev. H. H. Thomas, Vineland, N. J.
Dr. Geo. C. Laws, Paulsboro, N. J.
John H. Whitall, Woodbury, N. J.
Prof. John Enright, Freehold, N. J.
Charles Green, Pleasant Mills, Indiana (?)
Charles Shepherd, Bridgeton, N. J.
Edward S. Atwood, Water Witch Club, Highlands, N. J.
Wm. J. Leonard, Sea Bright, N. J.
Dr. North, 29 South Tennessee Ave., Atlantic City.
Geo. W. Price, Salem, N. J.
Ben A. Carpenter, R. D., Salem, N. J.
Mrs. Clarkson Pettit, Salem, N. J.
Geo. M. Andrews, Woodstown, N. J.
Harry Chambers, Moorestown, N. J.
Prof. Albert Robinson, Borough School, Allentown, N. J.
H. P. Lewis, 214 Washington St., Philipsbury, Pa.
Leslie Spier, 209 Dyckman St., New York City.
Edmund Shimp, 59 Myrtle St., Bridgeton, N. J.
P. K. Reeves, Bridgeton, N. J.
Frank Leaming, Cape May Court House, N. J.
C. C. Abbott, Trenton, N. J.
Max Schrabisch, 231 Broadway, Paterson, N. J.
Isaac Wort, Jr., Rossville, Staten Island, N. Y.
Clarence Woodmansie, Barnegat, N. J.
M. K. Cooper, Laurel-in-Pines Hotel, Lakewood, N. J.
I. O. Acton, Salem, N. J.
Mrs. Trueman Clayton, Alloway, N. J.
Chas. F. Pancoast, Woodstown, N. J.
Thos. V. Arrowsmith, Long Branch, N. J.
H. S. Long, 557 Rutherford Ave., Trenton, N. J.
F. W. Emley, Imlaystown, N. J.
Geo. Hampton, Bridgeton, N. J.
R. W. Emerson, 280 Cohansey St., Bridgeton, N. J.
Wm. Wright, Mount Holly, N. J.

Ernest Volk, Clinton St., Trenton, N. J.
Dr. Chas. Reed, 121 S. 17th St., Philadelphia, Pa.
Wm. T. Davis, 146 Stuyvesant Place, Tompkinsville, N. Y.
Jillson Bros., Tuckerton, N. J.
Clarence E. Seage, 143 Liberty St., New York City.
Hugh L. Reeves, Bridgeton, N. J.
Senator A. C. B. Havens, Toms River, N. J.
Mr. Havens, Burrsville, N. J.
Wm. J. Losell, Ed. of "Moorestown Chronicle," Moorestown, N. J.
David B. Bassett, Bassett, Gloucester Co.
Jonathan Kelsey, Pemberton, N. J.
N. M. P. Durling, Raritan, N. J.
Geo. Fountain, 936 West 1st St., Plainfield, N. J.
E. Vansyckel, Bound Brook, N. J.
Dr. Pardee, D. D. L., Bound Brook, N. J.
The Novelty Shop, Orange, N. J.
W. H. Fisher, Toms River, N. J.
Mr. Sapp, Tuckerton, N. J.
C. D. Sifficott, Swedesboro, N. J.
Chas. E. Cook, Asbury Park, N. J.
Wm. A. Slaughter, Mount Holly, N. J.
J. Hervey Buchanan, M.D., 43 Duer St., Plainfield, N. J.
Dr. G. Wyckoff Cummins, Belvidere, N. J.
Bert Britton, 104 Penna. Ave., Sunbury, Pa.
Marshall D. Weidman, Columbia, N. J.

INDEX.

(In this Index locality names refer to the occurrence of evidence of Indian occupation, except as otherwise stated.)

GEOLOGICAL SURVEY OF NEW JERSEY

HENRY B. KÜMMEL, State Geologist

in Co operation with

NEW JERSEY STATE AGRICULTURAL EXPERIMENT STATION

JACOB G. LIPMAN, Director

BULLETIN 10

The Mechanical and Chemical Composition of the Soils of the Sussex Area

NEW JERSEY

By

A. W. BLAIR and HENRY JENNING

Chemical Analyses

By

R. B. GAGE and H. C. McLEAN

Analysis of Soils—Methods Used

By

R. B. GAGE

Field work done in co-operation with the
Bureau of Soils of the U. S. Department of Agriculture

TRENTON, N. J.
MacCrellish & Quigley, State Printers, Opposite Post Office.

1913.

FOREWORD.

This bulletin constitutes a portion of the report on the soil survey of the Sussex area in North Jersey. The work has been conducted co-operatively by the Bureau of Soils of the United States Department of Agriculture, the Geological Survey of New Jersey, and the New Jersey State Agricultural Experiment Station. In conducting this survey, it has been the aim of the persons in charge to prepare a good soil map of the region, and to determine, further, the chemical nature of the several soil types. An agricultural canvass has also been made of the Sussex area, with a view to securing data relating to the practices that are likely to affect the fertility of the soils under consideration. The soil map and the accompanying discussion of the different types are being published as a separate report. A discussion of the mechanical and chemical composition of the soil samples, collected in the course of the survey, is presented in this bulletin; while a discussion of the results of the agricultural canvass is to appear as the third bulletin of this series.

As is shown by the analysis given in the following pages, the soils of the Sussex area are very often deficient in lime. They are well supplied with potash, containing, in many instances, enormous amounts of this constitutent. They are also well supplied with phosphoric acid, but frequently respond to applications of commercial fertilizer containing this constituent in an available form. The valley soils of the Sussex area are extremely fertile wherever they are properly drained. They are best suited for the production of hay and miscellaneous forage crops, and for dairy and beef cattle. They will also grow good crops of maize. Certain portions of these valley lands consist of muck or peat, now and then underlaid by shell marl. Such areas are well adapted for the growing of

onions, celery, lettuce and a number of other vegetable crops. The upland soils, where they are sufficiently deep and not too steep, are suited for the production of corn, small grains, forage crops and fruit. In general it may be said that the important agricultural industries of the Sussex area will consist, in the main, of dairying, poultry raising and fruit growing. The black valley soils will be utilized to a constantly increasing extent for the production of vegetables. The development of the soils of the Sussex area will depend on the recognition, on the part of the farmers, of the fact that most of their soils are sour and are badly in need of lime. The farmers will have to recognize, also, that the soils of the Sussex area are not as mellow as they should be, because of the insufficient amount of vegetable matter contained in them. For this reason, lime and green manures will be employed with success in the building up of these soils. The prevailing rotations will have to be modified, so as to permit a more frequent growing of leguminous crops. Soil improvement will thus be made possible with relatively slight expenditures for commercial fertilizers. A fuller discussion of the proper application of the facts discovered in the survey of the Sussex area, and practical suggestions for the improvement of the agricultural conditions in this region, will be given in the forthcoming report on the agricultural canvass of the Sussex area.

JACOB G. LIPMAN,
Director, New Jersey State Agricultural Experiment Station.

HENRY B. KÜMMEL,
State Geologist.

Soils of the Sussex Area, New Jersey.

BY A. W. BLAIR AND HENRY JENNINGS.

Contents.

DESCRIPTION OF THE AREA.

LOCATION.

The Sussex area is located in the extreme northern part of the State of New Jersey. Its northern boundary is the New York State line; on the west, Delaware River separates it from

Pennsylvania, while its eastern limit is longitude 74° 20′, and its southern, latitude 40° 56′. It embraces practically all of Sussex County, the northern part of Warren, western part of Passaic and Northern portion of Morris Counties. Its area is 788 square miles.

TOPOGRAPHY.

The Sussex area has five conspicuous topographic divisions, namely, Delaware Valley, Kittatinny Mountain, Kittatinny Valley, Highlands of New Jersey, and a portion of the Piedmont Plateau. The Delaware Valley covers all that portion of the area west of Kittatinny Mountain. It is marked by a steep ridge known as Wallpack Ridge, and also by flat terraces in the valley on the east and the Delaware River terraces on the west. Though of comparatively small area, this section offers possibilities for raising truck crops.

To the southeast of Delaware Valley, Kittatinny Mountain traverses the area in a northeast-southwest direction. A striking feature of this mountain is its even crest, which for miles has an average elevation of about 1,500 feet, but rises to a maximum of 1,809 feet at High Point. With the exception of Culvers Gap, a steep-sided wind gap, and Delaware Water Gap, the ridge is uninterrupted by any passes.

East of Kittatinny Mountain is a broad, rolling upland valley 10 to 13 miles in width, and 800 to 1,200 feet lower than the mountain, known as Kittatinny Valley. In general the altitude in the eastern part is from 300 to 600 feet below that portion next to Kittatinny Mountain. Seen from the high elevations which bound it on either side, it appears low and flat, but to one within the valley its floor is a succession of steep, rolling hills and ridges, trending in a general northeast-southwest direction, separated by several sub-valleys of considerable width and length. The chief streams follow these valleys, along which the tributary streams have dissected the intervening ridges. In its larger features its topography has been determined by its geologic structure, the higher elevations being underlain

by resistent shale and slate, while the sub-valleys are mostly of more soluble limestone.

Southeast of Kittatinny Valley is the elevated belt of country known as the Highlands of New Jersey. It occupies nearly one-half the area described in this report, and, although interrupted by several large valleys, it can be regarded as a unit. This region has an average elevation of 1,100 to 1,300 feet, above which rise rounded knobs to a maximum elevation of 1,496 feet, and below which the streams have eroded valleys of varying width and depth. Two of these, Vernon Valley, extending northeast from Hamburg to the State line, and the upper Wallkill Valley, stretching 10 miles southwest from Franklin Furnace, can be regarded as branches of Kittatinny Valley, which penetrate the west margin of the Highlands, and are separated from the main valley by semi-isolated mountain masses. Both of these valleys are narrow, not exceeding 2 miles in width, and of the two, Vernon Valley is of the most importance agriculturally.

Another important structural feature is the great valley extending southwest from Greenwood Lake to Newfoundland, Oak Ridge and beyond the limits of the area. In the vicinity of Newfoundland and Oak Ridge the valley widens greatly, and was at one time a section of considerable agricultural importance. Adjoining this valley are steep-sided, even-crested ridges, resembling in structure Kittatinny Mountain and known as Green Pond, Copperas, Kanouse and Bearfoot Mountains. Both they and the Greenwood Lake-Longwood Valley are due to a belt of limestone and shale, sandstone and conglomerate in the midst of the crystalline rocks which underlie most of the Highlands.

The fifth physiographic province represented is in the extreme southeast, where a small portion of the Triassic or red shale lowland is included in the region studied. Its elevation is about 180 feet and its area 2 square miles. Farther south this province develops into a broad, rolling lowland of excellent agricultural possibilities.

DRAINAGE.

The Sussex area is drained by tributaries of three river systems—Delaware, Hudson and Passaic. West of the Kittatinny Valley the drainage is into the Delaware, either direct or by small tributaries. In Kittatinny Valley the run-off goes into the Hudson or Delaware basins. The drainage of the northern part of the Kittatinny Valley goes into the Wallkill or its tributaries, which empty into the Hudson near Newburg. In the southern part of the valley the drainage is into the Paulinskill or Pequest River, and minor tributaries which empty into the Delaware at points south of the present area. The Pequannock River, the master-stream of the eastern section of the area, crosses the Highlands to the southeast. Much of its course is merely a rocky gorge along the sides of which there is barely room for a railroad and highway.

In addition to those mentioned there are many small streams which dissect the Highlands and eventually find an outlet into Passaic River.

The area is well supplied with natural lakes and ponds, of which Lake Hopatcong, Culvers Lake, Beaver Lake, Swartswood Lake and Macopin Lake are the most important. These lakes attract many city visitors during the vacation period.

In the upper part of the Pequannock drainage basin three large reservoirs have been constructed at Clinton, Oak Ridge, and Canistear. These supply the city of Newark with its water. Large tracts of land adjacent to these reservoirs have been purchased and at the present time are being reforested to prevent pollution and maintain the water supply.

CLIMATE.

The climate of the northern part of the State of New Jersey is moderately cold in winter and cool in summer. This climatic condition has an important influence in attracting city visitors during the summer vacation period. From data collected at the four climatological observation stations it appears that while it

is a comparatively small part of the State, there is a considerable difference in the length of the growing season within the boundaries of the area surveyed. This difference is especially noticeable in the length of the season between the first and last killing frost. At Layton the length of the growing season for a period of ten years has been 137 days without frost, at Charlotteburg 146, at Sussex 161, and at Newton 171. From field observations it appears that the difference even in the same location between low-lying lands and those at a greater elevation cannot be overemphasized. At the low levels frosts frequently kill corn and other tender crops, while fields at an elevation of 100 to 200 feet higher show little or no effect.

Where the ground is not properly drained during the winter season there is danger that grain crops will be heaved and winter-killed. In the spring, fruit buds are liable to be injured by late frost. The remedy for this would be the selection of sites which would retard the early development of the buds. The northwest slopes are several days later in the development of the buds than those to the southeast. This location, however, in many cases has the disadvantage of being exposed to the strong prevailing winds.

Precipitation, as a rule, is distributed quite evenly throughout the year, though there are occasional seasons when there are periods of drought. Usually damage done during these periods is especially noticeable on the lighter soils of the section. Ordinarily about 3 to 4 inches of rainfall can be expected during each month.

POPULATION AND TRANSPORTATION.

The settlement of Sussex area started about 1680, though the exact date is not definitely known. The present population, except at the quarrying and mining centers, is made up principally of the descendants of the original settlers with occasional representatives from some of the European countries. Satisfactory labor is difficult to secure on the farms, as it is claimed that the manufacturing industries offer better pay with shorter hours than the farm.

The towns of the area in order of importance are: Newton, Butler, Sussex, Blairstown, Franklin Furnace, Hamburg, Branchville, Ogdensburg, Andover, Sparta, Marksboro and Vernon, with numerous smaller hamlets.

The transportation facilities of the area are exceptionally good. The main and branch lines of the Delaware, Lackawanna and Western Railroad cross the area. Another direct line to New York is the New York, Susquehanna and Western Railroad, which connects from near the Delaware Water Gap to the eastern part of the area. The Lehigh and New England Railroad traverses Kittatinny and Vernon valleys from the north to the south. Other smaller roads furnish connections to various points.

AGRICULTURE.

The Sussex area was first developed agriculturally in the upper Delaware Valley, according to Small's "History of Sussex and Warren Counties." This was about 1680, though the exact date is not definitely known. From the beginning of settlement in the area agriculture was the leading industry, though the section was prospected and its mineral resources recognized at an early date. The early settlers, who were Dutch, Huguenots, German, Quaker and Puritan, raised a diversity of crops, mainly subsistence crops. During these early times the farm implements were few and of very rude construction. The ground was scratched rather than cultivated. The products sold were usually such as could be easily transported to more or less distant markets. It was frequently necessary to undertake long, tedious trips extending through several days. The soils are naturally adapted to grass, and this was fed to cattle, which, after being fattened, were driven to market.

When the agricultural resources became known the Sussex area, especially Kittatinny Valley, attracted so many settlers that production could not keep pace with the subsistence needs of the population. In 1790 the area comprising Sussex County had a population exceeded by but one county in the State. About

this time grist mills were erected on the valuable power sites in various parts of the area. This gave an impetus to the growing of grain which could be sold at remunerative prices.

The following figures showing the changes in the agriculture of Sussex County give a good idea of the growth of the agriculture of the area as a whole.

In 1825 it is estimated that the principal exports of Sussex County were 900 tons of butter and 3,000 tons of pork and other meat. At this time such products as milk, young calves, poultry, eggs and potatoes were of little value except for consumption on the home farms. Fruits were grown successfully, but comparatively little use was made of them. Indian corn, timothy and clover were not introduced into the county until a comparatively late date.

The plow and harrow used in 1825 were of about the same construction as those used by the early settlers, showing a slow development. Nevertheless, there were advances in the scope of agricultural practices during the first fifty years of the nineteenth century. It was recognized that the drowned lands had great value and possibilities as early as 1804, though their development did not take place until a much later time.

Until the railroads entered the county the principal products sold continued to be beef, butter and swine. The milk produced was skimmed and fed to pigs, while the cream was made into butter. These products were easily transported and brought good prices. Very soon after the railroads entered the area the shipment of milk was started. This industry has increased, especially in Sussex and Warren Counties. In 1870 1,317,791 gallons were shipped from Sussex County, and in 1900 12,588,855 gallons. The following figures relating to the agriculture of the area are taken from the census reports of the United States for the years indicated:

	1850.	1860.	1870.	1880.	1890.	1900.	1910.
Acres improved,	149,582	175,894	157,403	180,846	191,743	178,431	161,283
Acres unimproved,	94,895	86,335	....	72,842	55,997	78,465	77,028
Cash value of farms and buildings,	$8,390,180	$11,105,233	$13,264,703	$9,801,524	$7,748,320	$6,834,120	$8,358,090
Value of implements,	$213,465	$292,290	$356,810	$291,946	$345,580	$393,010	$553,836
Value of live stock,	$1,049,719	$1,396,472	$1,660,947	$1,052,293	$1,171,360	$1,406,100	$1,949,874
Value of all products for year,	....	....	$2,526,710	$1,670,239	$1,745,830	$1,149,250	....
Value of dairy products,	....	....	....	....	....	....	....
Value of orchard products,	$3,307	$18,896	$39,701	$40,521	....	$104,941	....
Number of horses,	4,390	5,026	4,230	4,546	4,785	6,288	4,785
Number of neat cattle,	25,549	29,129	22,213	26,003	28,597	32,195	33,353
Number milch cows,	16,816	19,240	17,376	18,903	21,264	22,013	22,972
Number sheep,	8,309	6,127	3,976	5,171	5,131	4,832	2,960
Number swine,	30,115	25,164	14,414	17,028	12,735	6,512	4,958
Bushels corn,	459,254	505,341	432,776	571,484	398,737	527,770	486,825
Bushels oats,	151,011	274,915	268,477	229,534	222,675	130,090	134,224
Bushels rye,	229,795	238,232	105,306	98,300	70,471	71,390	53,286
Bushels wheat,	66,006	25,167	64,508	30,560	18,606	20,670	16,815
Bushels potatoes,	110,020	113,093	81,006	94,788	52,767	150,241	96,913
Tons hay,	37,711	43,078	40,335	40,059	59,945	39,081	62,093
Bushels buckwheat,	178,188	142,552	72,870	119,899	35,977	63,220	48,695
Gallons milk,	....	....	1,317,791	4,183,145	10,797,483	12,588,855	....
Pounds butter,	1,816,610	2,042,987	1,455,788	1,190,571	697,362	342,916	....
Value of fertilizer,	....	....	....	$10,077	$3,028	$14,940	$19,803

GEOLOGY OF THE AREA.

SOILS.

Origin.—The soils of the Sussex area are chiefly, although not entirely, of glacial origin. During the glacial period the moving ice field, as it slowly advanced, tended to drag along with it the soil which had been formed in pre-glacial times by the disintegration and decomposition of the various underlying rock formations. Armed with this material, the ice sheet, acting as a flexible rasp, tended to break and grind off even the solid rock itself. As it advanced some of this material lodged under the ice and new material was picked up, while at the front edge of the glacier, where the melting equaled the rate of advance, this rock débris accumulated in an ever-increasing amount. In places where the drainage from the ice was concentrated along certain lines the finest part of the material was swept away by the swiftly-flowing water, and the coarser material was deposited as sand and gravel. As the rate of melting gradually exceeded the rate of advance, and the front of the ice sheet receded, a mantle of débris, coarse and fine indiscriminately mingled and of varying thickness, was deposited. This sheet of stony clay, technically called till, and the beds of clay, sand, and gravel deposited by the streams issuing from the ice sheet form the basis of most of the present soils of the Sussex area.

The till is composed chiefly of material derived from the rock formation on which it rests. While this is true, it also contains a considerable percentage of material derived from more remote regions which the ice had carried longer distances. In general, the thinner the till the greater the proportion of local material. Inasmuch as the grinding action of the ice is great, all material (except the very hardest) which was transported far was ground to powder. Hence the percentage of distantly derived material is larger in the finer portion of the till than it is in the coarser portion.

Inasmuch as the ice which reached this region traversed rock formations of many kinds, and since the region itself contains a number of geological formations, the till presents several distinct

phases which depend chiefly upon the character of the underlying rock.

Locally, the mantle of glacial drift was so thin that the present soil is practically the result of the decay and disintegration of the underlying rock. Essentially the same result occurs in those areas where the till is almost entirely of local material, and the admixture of foreign material is extremely limited. In such cases the soil or subsoil, although technically derived from glacial material, may not be greatly unlike a soil or subsoil resulting solely from the disintegration of the rock beneath.

The upland types of soil fall naturally into soil series based generally on geological differences which influence their structure and general characteristics. They are closely related to the underlying rock formations which have entered so largely into the glacial till from which the soils were principally derived. A second class of soil formations is made up of materials derived from deposits of glacial waters, during and immediately following the recession of the ice. These are classed as terrace soils. A third group of soils comprises those derived from material eroded from higher localities and deposited, for the most part, during high water on the bottom lands along the streams.

CLASSIFICATION OF SOILS.

The detail soil survey consists in indicating on a map the location and extent of the different soil types.

The unit in the soil survey is the soil type which possesses certain more or less definite characteristics. In the determination of the soil type several factors are taken into consideration. These are (1) geological origin of the soil, whether residual, glacial, or alluvial; (2) texture which deals with the porosity, granulation, friability and their relation to the physical or mechanical composition of the soils, such as the percentage of gravel, sand, silt or clay; (3) structure which deals with the arrangement of the soil particles; (4) the organic content; (5) color; (6) depth; (7) drainage; (8) topographic position as it affects agricultural value; (9) native vegetation, as tree growth and kind; (10) chemical composition and reaction.

Many types in a given section will grade one into another with respect to many of these characteristics.

Soil types may be grouped in several different ways. Soils because of being composed of particles of different size may be grouped according to the relative proportion of the particles of the different sizes which they contain. This classification or grouping is known as the soil class and is based on texture.

The mechanical analysis of soils is the process of separating the soil particles less than 2 mm. (2/25 of an inch) into seven grades and determining the various percentage relations in order to determine the class to which the soil belongs. In this way it is determined whether it is a sand, loam, clay or some intermediate class. In addition to the fine earth many soils contain large particles which, if of comparatively small size, are called "gravel," and if of large size are called "stones." Because the different classes grade into each other, the line of separation between classes is necessarily an arbitrary one.

It has been found that certain sets of soil classes are so closely related as to source of material, method of formation, topographic position and coloration that the different types constitute merely a gradation in texture of an otherwise uniform material. Soils of this character are grouped together into what is called a soil series. A complete soil series consists of material similar in many other characteristics but grading in texture from stones and gravel through different grades of sands and loams to heavy clay.

Color characteristics form one of the most noticeable physical features, and are of great assistance in separating the soils into different series.

Soil Constituents.	Organic Matter (composed of vegetable and animal remains.)		
	Inorganic Matter, (Used in mechanical analyses.)		mm.
		Clay,	0.005—0
		Silt,	0.05—0.005
		Very Fine Sand,	0.1—0.05
		Fine Sand,	0.25—0.1
		Medium Sand,	0.5—0.25
		Coarse Sand,	1—0.5
		Fine Gravel,	2—1
	Gravel.		
	Stones.		

CLASSIFICATION OF SOILS, BASED UPON THEIR MECHANICAL COMPOSITION.*

CLASS.	1 Fine Gravel 2–1 mm.	2 Coarse Sand 1–0.5 mm.	3 Medium Sand 0.5–0.25 mm.	4 Fine Sand 0.25–0.1 mm.	5 Very Fine Sand 0.1–0.05 mm.	6 Silt 0.05–0.005 mm.	7 Clay 0.005–0 mm.
Coarse sand,	More than 25% of 1 and 2.		Less than 50% of 3, 4 and 5.			Less than 20% of 6 and 7.	
Sand,	More than 25% of 1, 2 and 3.			Less than 50% of 4.	...	Less than 20% of 6 and 7.	
Fine sand,	Less than 25% of 1, 2 and 3.			More than 50% of 4.	...	Less than 20% of 6 and 7.	
Very fine sand,	...	...	...	...	More than 50% of 5.	Less than 20% of 6 and 7.	
Sandy loam,	More than 25% of 1, 2 and 3.			...	...	20 to 50% of 6 and 7.	
Fine sandy loam,	Less than 25% of 1, 2 and 3.			More than 50% of 4.	...	20 to 30% of 6 and 7.	
Sandy clay,	...	...	...	...	...	Less than 20% of 6.	
						20 to 50% of 6 and 7.	
Loam,	...	...	...	...	...	Less than 50% of 6.	Less than 20% of 7.
						More than 50% of 6 and 7.	
Silt loam,	...	...	...	...	...	More than 50% of 6.	Less than 20% of 7.
						More than 50% of 6 and 7.	
Clay loam,	...	...	...	...	...	Less than 50% of 6.	20 to 30% of 7.
						More than 50% of 6 and 7.	
Silty clay loam,	...	...	...	...	...	More than 50% of 6.	20 to 30% of 7.
						More than 50% of 6 and 7.	
Clay,	...	...	...	...	...	...	More than 30% of 7.
						More than 50% of 6 and 7.	

* From U. S. D. A. "Soil Survey Field Book," 1906, pp. 17 and 18; and U. S. D. A. "Bulletin No. 78, Bureau of Soils," p. 12.

SOIL ANALYSIS AS RELATED TO CROP PRODUCTION AND SOIL IMPROVEMENT.

Much has been said both in favor of and against the chemical analysis of soils as a means of determining their plant food requirements. It is generally admitted that while such an analysis does show the total amount of plant food present, it fails, on the other hand, to show how much is available for the immediate demands of the plant. For this latter reason some have held that there is little value in the chemical analysis of soils.

If by chemical analysis is meant the analysis of a single sample taken from only one spot on the farm, by a person not skilled in such work, then the value of such analysis may indeed be questioned. Much care and good judgment should be exercised in taking the samples, for if they do not represent the type, then the analysis cannot be considered reliable, and is, consequently, of little value.

If, on the other hand, the samples are carefully collected by a person skilled in this kind of work, then the results of a chemical analysis, when interpreted in the light of crop requirements, cannot fail to be of value when we come to the subject of laying out systems of soil improvement and putting up fertilizer mixtures for special crops.

To make this clear we may suppose that analysis has been made of two samples of soil, one of which yields 0.2% of total potash and the other 2.5%. (Such differences actually occur in the soils of New Jersey.) The 0.2% found in the first soil is equivalent to 4,800 pounds of potash in an acre to a depth of 8 inches (approximately 2,400,000 pounds of soil). The 2.5% is equivalent to 60,000 pounds of potash in the same amount of soil. Here is a difference between the two soils of nearly 28 tons of potash. Is there anyone who has studied the subject carefully and is willing to say that there is no difference in the treatment which the two soils should receive and the kind of crops which will give the best returns? It must be admitted that in neither case do we know how much of this potash is available for the immediate needs of the plants. However, until the con-

trary has been fully proved it is fair to assume that the second soil will yield more available plant food than the first. Certainly we know with respect to the second soil that here is a vast store of reserve potash, and if by cultural methods and the application of soil amendments we can render only a small fraction of this reserve supply available each year, we shall have an abundant supply for most crops, and at the same time we need have little fear of the exhaustion of the supply for many years to come. If our analysis shows that the subsoils contain as much or more potash than the soils, we find that we have here in an acre to the depth of 20 inches the enormous supply of 150,000 pounds (75 tons) of actual potash. With this information before us we can, at intervals, put in crops which will send their roots down into the subsoil and bring up some of the reserve supply; we can plow deep without fear of going beyond the supply of plant food, and we can employ cultural methods which will bring about a movement of the capillary moisture toward the surface.

With respect to the first sample, we find that the total supply of potash to the depth of 8 inches would be practically exhausted by 60 crops of potatoes. Here it would undoubtedly be necessary to supplement the natural supply by the addition of soluble potash salts. Thus our analysis may lead to entirely different treatment for the two soils.

In the same way analysis may show that one soil contains only 0.03% of nitrogen, equivalent to 720 pounds per 8-inch acre, while another may contain 0.2%, equivalent to 4,800 pounds per 8-inch acre. In the first instance it will be necessary to apply nitrogen in the form of commercial fertilizer for almost any crop that may be grown; in the second soil there is a liberal reserve supply, which, it is true, may not be readily available, but it is a potential factor which may be reckoned with in the cultivation of that soil. With proper cultural methods we may expect to render a part of this nitrogen available for each crop, and thereby reduce the bill for commercial fertilizers. If the analysis has shown that the soil is low in nitrogen and organic matter, it is an indication that the supply of humus is low. With this information at his command, the farmer can set out

to restore the humus by the application of manure and by the use of leguminous crops, which will also increase the supply of available nitrogen.

On the other hand, if analysis shows that the soil is well supplied with organic matter, light is thrown on the important question of water-supply, the abundance of useful organisms, the depth to which we may safely plow, the time of planting, etc.

It is not here maintained that a "complete" analysis of soil is necessary, nor is it claimed that the farmer should be left to interpret the results for himself. A plea is made, however, for the determination of certain constituents, a knowledge of which, with careful interpretation, will enable the farmer to handle his soil in a more intelligent manner. It must be remembered, however, that no amount of plant food that is naturally present in the soil, or that applied as commercial fertilizers, can compensate for careless, indifferent methods of soil management.

THE SOIL AS A SOURCE OF PLANT FOOD.

In the following pages will be found the chemical analyses of a large number of samples of soil representing the various types recognized in the Sussex area. As has already been pointed out, the chemical analysis gives us a knowledge of our resources which cannot be gained in any other way. A mechanical analysis throws much light on the agricultural possibilities of a soil, but there is still lacking a definite knowledge of the resources at our command. A summary of the agricultural methods in actual practice also gives us much valuable information on the subject, but we cannot always construct on these practices a safe plan of soil improvement, nor rely upon them to give us maximum crop returns, for again, in many instances, these practices are not based on a knowledge of the actual agricultural possibilities of the soil, but rather upon the customs of the community for a generation past. Just as the expert bookkeeper knows all the assets and liabilities of his company, so should the agricultural expert know all the assets and liabilities of the soil; that is, he should be familiar with the present agricultural practices; he

should know the composition of the soil, both chemical and physical, and the composition and feeding habits of the crops to be grown; he should know the amount of rainfall and be familiar with the climatic conditions and topography of the country. Possessed of these facts, he can plan systems of soil improvement and crop extension which will be far-reaching in their results.

POTASH.

Analysis shows that the soils of the Sussex area are, almost without exception, rich in potash. Rarely is the total less than 1.5% and often it reaches 3.00% and over. It is further found that the subsoils are in most cases richer in this material than the soils. From these figures it may be shown that an acre to the depth of 20 inches contains about 90,000 to 180,000 pounds (45 to 90 tons) of actual potash. This is reserve capital which may be drawn upon by crops for hundreds of years without fear of exhaustion. It must be admitted that this is largely unavailable for crops at the present time, and that it may even be necessary to add some soluble potash fertilizers in some cases, but knowing that potash is present in large quantities, and knowing that mineral matter—even the solid rock—is constantly decomposing under the action of atmospheric agencies, we can adopt such methods and such systems as will aid in setting free this locked-up plant food. It is well known, for example, that under certain conditions, lime will take the place of potash in these comparatively insoluble minerals, thus liberating the potash so that it forms compounds which can be assimilated by the plant. Since the analysis shows most of these soils to be naturally deficient in available lime, we can with confidence lay down the proposition that an application of lime or ground limestone will put into circulation for plant growth some of this stored-up potash capital. It is equally well understood that when organic matter decays in the soil carbon dioxide is formed, and when dissolved in the soil water acts as a solvent for the mineral matter of the soil. In this connection Clarke[1] says: "In a fertile region organic matter is abundant, and great quantities of carbonic acid are

[1] The Data of Geochemistry, p. 72. See also Rocks, Rockweathering and Soils, by G. P. Merrill, pp. 237–38, and Soils, by E. W. Hilgard.

generated by its decay. This carbonic acid absorbed by the ground water of the soil, acts as a solvent of mineral matter, and carbonates are carried into the streams more abundantly than other salts." There is abundant proof that percolating ground waters do remove large quantities of mineral matter from the soil. Clarke[1] cites calculations made by T. Mellard Reade, on the amount of solid matter annually dissolved by water from the rocks of England and Wales. He estimates that the total annual run-off from the area in question carries in solution 8,370,630 tons of dissolved mineral matter, or 143.5 tons for each square mile of surface. Clarke[2] also reports the amount of saline matter carried annually to the sea by four American rivers, the St. Lawrence, Potomac, Mississippi and Colorado, as 143,834,400 tons, an amount equal to 79.6 tons per square mile. Sellards[3] estimates that from Central Peninsular Florida dissolved mineral matter is being carried into the sea at the rate of a little more than 400 tons per square mile annually. In this connection he says: "That underground water is efficient as a solvent is evident from the analyses of well and spring waters. Rain water entering the earth with almost no solids in solution returns to the surface through springs and wells with a load of mineral solids in solution determined by the length of time it has been in the ground, the distance traveled and the character of the rocks and minerals with which it comes in contact."

Since carbon dioxide, which results from the decay of organic matter in the soil, aids in bringing into solution the mineral constituents required by plants, it follows that increasing the organic matter in a soil naturally well supplied with potash, will aid in making this potash available. This organic matter can be supplied in the form of stable manure and green manure crops to be turned under. On such soils as the majority of those encountered in the Sussex area it is doubtful if soluble potash salts will be required to any great extent provided proper cultural methods are adopted.

[1]Loc. cit., p. 89.
[2]Loc. cit.
[3]Preliminary Report on the Underground Water Supply of Central Florida. Florida Geological Survey, Bull. No. 1.

PHOSPHORIC ACID.

The soils of the Sussex area are usually well supplied with phosphoric acid. From the tables of analyses it will be seen that there is in most cases about 0.12 to 0.16% of this compound soluble in strong hydrochloric acid in the surface 8 inches, while the amount in the section 12 to 20 inches is almost invariably a little lower. If we assume that the average is represented by the lower figure, 0.12%, it means that in an acre to the depth of 20 inches there are 7,200 pounds of phosphoric acid. Since the average crop removes not more than 15 pounds of phosphoric acid per acre it is plain that we have here in the surface 20 inches enough phosphoric acid for nearly 500 crops. Taking Hilgard's estimate of 0.11% of phosphoric acid as a fair average for soils in humid regions, it is seen that the soils of the Sussex area are slightly above the average in this constituent. As in the case of the potash it must be admitted that much of this phosphoric acid is not immediately available, but with the proper methods of handling, it will gradually become available, so that usually only light applications of phosphates will be required.

LIME.

With reference to lime Hilgard says that in humid soils it varies from 0.1% in light sandy soils to 0.25% in clay loams, 0.3% in heavy clay soils, and that it may even rise to 1 or 2 per cent. to advantage. Judged by this standard most of the soils of the Sussex area are deficient in lime, at least in what we may term available lime.

As has already been intimated applications of lime would tend to make available some of the large supply of potash which is found here; it would also correct any acid condition which may exist, and put the soil in a more favorable condition for the beneficial bacteria which are such an important asset to the farmer in rendering plant food available. There are outcrops of limestone in many places in this section of the State, and this could easily be burned for use as lime, or ground fine to be used in the raw form.

A study of the soil analyses reported in the following tables shows that in nearly all the samples the magnesia is distinctly in excess of the lime. An exception to this rule is noted in the muck soils where the lime is in excess of the magnesia. In a few cases, notably the Gloucester stony sandy loam and the Genesee loam the magnesia is only slightly in excess of the lime so that the ratio is usually 1 to 1 and a fraction. In many of the samples the ratio is about 1 to 3 or 4, while in others it is 1 to 10 or 12, and in some as high as 1 to 24.

In this connection the question naturally arises, does this excess of magnesia over lime render these soils less productive than they otherwise would be? If Loew's theory that fertile soils generally show an excess of lime over magnesia is correct, then may it not be possible to increase the productiveness of these soils by heavy aplications of lime?

MAGNESIA.

Although magnesia is not usually regarded as a plant food in the same sense that nitrogen, phosphoric acid and potash are, still its almost entire absence, or its presence in large amounts, may have a marked influence on crop production.

In this connection Loew[1] says: "An excess of magnesia acts injuriously on plants, an observation made frequently and long ago. The increase of lime is the only decisive remedy. The plants thrive best when the ratio of lime to magnesia does not pass certain limits. Too little magnesia in relation to lime may retard development, while too much magnesia in relation to lime may injure the crop still more." On page 15 the same author says: "Every farmer ought to know the ratio of the easily assimilable portion of lime to magnesia in his soil, as with such knowledge he can tell when liming is needed and if magnesia will prove injurious. Soils with much magnesia are more to be feared than those with too little." After discussing the relation of lime to magnesia in many soils from various parts of

[1]Liming of Soils from a Physiological Standpoint. Bull. No. 1, Bureau of Plant Industry, U. S. D. A., p. 10.

the United States and foreign countries, Loew[1] says: "It will be seen from the above review—

1. That the ratio of lime to magnesia ranges between wide limits.

2. That in the majority of cases lime predominates over magnesia.

3. That in all the instances of great fertility the soil never shows any marked excess of magnesia over lime, but, on the contrary, generally more lime than magnesia."

The following from May's[2] Summary of results from his studies of the relation of lime and magnesia to plant growth bears directly on this question: "Soil analyses show that lime and magnesia are widely distributed in soils and generally in sufficient quantities for the direct needs of plants. They are not always in the best proportions to each other from a physiological standpoint, for favoring plant growth. Magnesia in a soil in great excess over lime in a finely divided or soluble condition is noxious to the growth of plants. With a great excess of lime over magnesia the physiological action of the plant is hindered and it exhibits phenomena of starvation. An excess of lime counteracts the poisonous effects of magnesia, while the more favorable proportion of the two bases obviates the poor nutrition of the plant.

The best proportion of soluble lime to soluble magnesia for the germination and growth of plants is about molecular weight 5 to 4, or actual weight 7 to 4."

Hilgard[3] says: "In the case of soils containing much magnesia, the proper proportion between it and lime may be disturbed by the greater ease with which lime carbonate is carried away by carbonated waters in the subsoil, thus leaving the magnesia in undesirable excess in the surface soil. Hence the great advantage of having in a soil, from the outset, an ample proportion of lime. From this point of view alone, then, the analytical determination of lime and magnesia in soils is of high practical value."

---

[1] Loc. cit.

[2] Experimental—Study of the Relation of Lime and Magnesia to Plant Growth. Bull. No. 1, Bureau of Plant Industry, U. S. D. A.

[3] Soils, p. 383.

Discussing the results obtained on the lime-magnesia ratio as influenced by concentration, Gile[1] says: "From this work it appears that we have to do not so much with the ratio of lime to magnesia as we have to do with the relation between whatever salt is in excess and all the other salts. That is, the question is not the simple one of a balancing of lime with magnesia, but a balancing of lime or magnesia with all the other nutrients. If the mere ratio in which lime and magnesia are present is the only factor operative, we should anticipate the yield to be affected by the ratio of these two salts in dilute as well as in concentrated solutions and independently of the other salts present. Such however, was not found to be the case. The facts, then, seem to point to the following conclusions: The toxicity of an excess of lime or magnesia is not due simply to an unfavorable ratio between these two salts alone, but to an unfavorable proportion between the salt which is in excess and all the other salts present."

In some pot experiments conducted at the New Jersey Experiment Station[2] it has been shown that magnesia, in excessive amounts, does have an injurious effect upon plant growth, and further that this injurious effect may be counteracted to some extent by the use of lime. The question cannot be fully answered, however, until field experiments have been conducted with a view to determining just what will be the effect of applications of lime to these soils in which there is an excess of magnesia. The question involved emphasizes the importance of determining the amount of lime and magnesia in soil-survey work.

NITROGEN.

One-tenth of one per cent. of nitrogen is, by some authorities, considered adequate for soils in humid regions. The surface soils of the Sussex area are above this amount, on the average. Even the subsoils—12 to 20 inches—usually contain 0.04 or 0.05%, which is as much as is frequently found in surface soils. If we take the average amount of nitrogen in all the soils as 0.15%,

[1]Gile, P. L. Porto Rico Agrl. Expt. Station, Bulletin No. 12, p. 23.
[2]Report Soil Chemist and Bacteriologist, 1911.

we find that an acre to a depth of 8 inches contains 3,600 pounds of nitrogen. While this amount may at first thought seem large, we must not overlook the fact that nitrogen, more than any other of the materials, is being constantly leached out of the soil, and that the average crop will remove 40 to 60 pounds of it. Furthermore, much of this nitrogen is in the form of undecomposed vegetable matter and is not available except as it is gradually transformed into nitrates by natural agencies at work in the soil. A more liberal use of lime and deeper and more thorough cultivation will aid in transforming this nitrogen into plant food. With the more general use of leguminous crops to restore the humus thus used up, and to add to the stores of nitrogen already present, it should not be necessary to use large amounts of nitrogenous commercial fertilizers on these soils.

SOIL SERIES REPRESENTED.

The following series and types of soil occur in the Sussex area.

Till Soils	Dutchess	Loam Shale Loam Stony Loam
	Dover	Loam Stony Loam Fine Sandy Loam
	Gloucester	Loam Sandy Loam Stony Loam Stony Sandy Loam
	Wallpack	Silt Loam Stony Loam Shale Loam Fine Sandy Loam
	Lackawanna	Loam Stony Loam
Reworked Materials	Hoosic	Loam Sandy Loam Gravelly Loam
	Chenango	Loam Fine Sandy Loam Sandy Loam Silt Loam Fine Sand Sand
	Fox	Gravelly Loam

Alluvial Soils..........	Genesee Loam Papakating Silt Loam Wallkill Silty Clay Loam

Muck.

The distribution and character of the above soils are given in a separate bulletin on the Report on the Soil Survey of the Sussex Area, to which reference should be made for further data regarding them. The following discussion relates mainly to their mechanical and chemical constitution.

DUTCHESS SERIES.

The Dutchess soils are found in Kittatinny Valley and are characterized by the presence of varying quantities of slate and shale, differing with the individual type. The surface soils are grayish-brown when moist, becoming decidedly gray on drying. With the exception of the small area in the neighborhood of Postville, the series is confined to Kittatinny Valley. The types recognized are the loam, shale loam and stony loam.

Following are the results of the mechanical analyses of a series of samples of these soils collected during the survey:

RESULTS OF MECHANICAL ANALYSES OF REPRESENTATIVE SAMPLES OF THE DUTCHESS SERIES.

Soil Type.	Soil Number.	Coarse Gravel. Over 2 mm.	Fine Earth. Und. 2 mm.	Fine Gravel. 2–1	Coarse Sand. 1–0.5	Medium Sand. 0.5–0.25	Fine Sand. 0.25–0.1	Very Fine Sand. 0.1–0.05	Silt. 0.05–0.005	Clay. .005–0.000
		Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Loam, 0–8 inches, ...	99	16.4	83.6	2.9	4.1	3.1	10.0	17.3	45.4	17.0
Loam, 12–20 inches, ...	100	13.7	86.3	2.0	4.2	3.8	10.4	11.0	46.2	21.4
Loam, shaley phase, 0–7 inches, ...	95	23.3	76.7	6.0	5.0	3.2	7.5	6.3	54.9	16.9
Loam, shaley phase, 12–20 inches, ...	96	38.5	61.5	6.1	6.3	3.8	8.3	9.9	46.6	18.9
Shale loam, 0–7 inches, ...	119	45.2	54.8	8.4	5.9	3.8	7.8	5.9	49.7	18.4
Shale loam, 12–20 inches, ..	120	67.9	32.1	13.4	10.1	5.5	10.1	10.4	29.9	20.5

Dutchess Loam.

Chemical analyses of six soils and eight subsoils of the Dutchess loam type, taken from different localities are given in table on p. 32. From the analyses, averages have been made which will enable us the more easily to compare the soil with the subsoil and also this with other types.

The difference between the amount of insoluble matter in the soil and subsoil, as shown by these averages, is not great. There is in the soil 0.28% and in the subsoil 0.45% of potash soluble in strong hydrochloric acid, and 1.44% and 2.15% respectively of total potash. From this it appears that approximately one-fifth of the potash present is soluble in strong acid. This amount is above the average usually set for potash in the soils of the humid regions. It will be observed, too, that there is more potash in the subsoil than in the soil, both acid soluble and total. With proper treatment as to cultural methods, such a soil should require a minimum amount of potash in the form of commercial fertilizers. The averages show that this type is very deficient in lime, the average for the soils being only 0.08%, while several of the subsoils contain only a trace. Magnesia, on the other hand, is present in much larger amounts.

From the averages we find that the ratio of lime to magnesia in the soil is 1 : 8.5 and in the subsoil 1 : 5.1. We may also note here that there is more lime in the soil than in the subsoil, while the opposite is true of the magnesia.

There is more alumina than iron present in both soil and subsoil, and more of each in the soil than in the subsoil. The phosphoric acid soluble in strong hydrochloric acid is, in the soil, 0.135% and in the subsoil 0.107%, while the total phosphoric acid is slightly more in each case. Since Hilgard's standard for phosphoric acid in a productive soil is about 0.10%, it is seen that these soils, when judged by this standard, come well within the limits with respect to phosphoric acid. Hilgard further points out that a large supply of lime or humus or both may offset a smaller percentage of phosphoric acid, apparently by bringing about a greater availability.

The nitrogen in the soil is 0.161%, which is more than one and one-half times the 0.10% which Hilgard considers ordinarily adequate. In the subsoil it is 0.05%. If we assume that an acre of land to a depth of 8 inches weighs 2,400,000 pounds, we find that an acre of this soil to the depth of 8 inches contains 3,864 pounds of nitrogen. The carbon dioxide is so low as to be almost negligible, and we may therefore regard the total carbon as organic carbon. Of this there is 1.8%, which is equivalent to 43,680 pounds of carbon in an acre to a depth of 8 inches.

With the exception of lime, this type of soil is fairly well supplied with those substances which are generally considered under the head of fertilizers and soil amendments. The liberal use of lime would no doubt improve the physical condition of the soil and at the same time it would aid in making the other materials more available, especially the potash and nitrogen. In connection with lime, legumes could be used to good advantage to increase the supply of available nitrogen.

Dutchess Loam (shaley phase).

This type is represented by four samples of soil and four of subsoil. It is quite similar in chemical composition to the shale loam. Slight differences are to be noted, however. It is poorer in lime, magnesia and nitrogen, but is richer in phosphoric acid. It contains in the soil on the average about nine times as much magnesia as lime. The total phosphoric acid present is equivalent to about 5,000 pounds per 8-inch acre, while the nitrogen is equivalent to nearly 4,000 pounds per 8-inch acre. The total carbon present is equivalent to nearly 45,000 pounds per 8-inch acre, and this carbon is practically all of organic origin. This may be looked upon as a source of humus, though no doubt much of it is very old and therefore decays with exceeding slowness. As already pointed out, applications of lime will aid in the decomposition of this organic matter, but of even greater value in improving these soils will be a more general use of green manure crops to furnish a readily available supply of humus and nitrogen.

Dutchess Shale Loam.

This type is quite similar in composition to the loam. There are, however, a few differences which may be pointed out. There is distinctly less insoluble matter, the amount in both soil and subsoil being less than 80%. This is due in part at least to the fact that these soils contain more iron and alumina and more volatile matter than the loam soils. It also probably indicates a soil of somewhat finer texture.

The ratio of acid soluble to total potash is 1 : 4.72 and 1 : 5.3 in the soil and subsoil respectively. The ratio of lime to magnesia is 1 : 7.7 and 1 : 19 in the soil and subsoil respectively.

The potash, lime and magnesia in the surface soil are one-third to one-fourth higher in this type than in the loam, while the iron and alumina, as already pointed out, are distinctly higher. There is here, as in the loam, more alumina than iron and more of each in the subsoil than in the soil. The phosphoric acid in the soil is slightly less than in the loam, but if we take an average of the soil and subsoil we find that the two types are about the same; there is in each case a little more total than acid soluble phosphoric acid. In the soil there is 0.213%, and in the subsoil 0.07% of nitrogen. This is an unusually high percentage and is equivalent to approximately 5,000 pounds of nitrogen in an acre to the depth of 8 inches. The total carbon which, on account of the small amount of carbon dioxide may be considered as organic carbon, is distinctly higher than in the loam.

This soil contains more potential or reserve plant food than the loam, and there is good reason to believe that with liming, good cultural methods, and the use of legumes, it will yield excellent crops.

DUTCHESS LOAM.

Location,	1½ Mi. S. W. of Unionville. 22-12-3-6-8-6*		½ Mi. East Drake's Pond. 22-31-5-7-2-6		2 Mi. N. Quarryville. 22-12-3-6-8-6		1 Mi. S. E. of Lafayette. 22-31-3-6-1-7		¾ Mi. N. Branchville. 22-21-4-2-7-5		½ Mi. N. W. of Greenville. 21-44-3-4-8-8				Average.	
Depth of Sampling,	0–8″	12–20″	0–8″	12–20″	0–8″	12–20″	0–8″	12–20″	0–7″	12–20″	0–8″	8–18″	18–28″	28–36″	Soil	Sub-soil
Soil Number,	53	54	65	68	85	86	99	100	103	104	125	126	127	128		
Insoluble Matter,	80.34	86.28	82.62	81.83	83.70	87.02	88.22	84.39	81.64	86.25	80.39	82.69	82.97	82.93	82.82	84.30
Soluble Silica, SiO_2,	.05	.06	.06	.05	.03	.04	.05	.05	.06	.07	.05	.03	.04	.02	.05	.045
Potash, K_2O,	.33	.40	.27	.22	.31	.38	.21	.41	.25	.36	.33	.59	.62	.65	.28	.45
Soda, Na_2O,	.06	.07	.09	.07	.09	.09	.09	.11	.10	.10	.07	.09	.06	.07	.083	.082
Lime, CaO,	.09	.05	.08	.05	.02	.02	.05	.04	.01	.01	.23	Trace	Trace	Trace	.08	.02
Magnesia, MgO,	.72	.92	.62	1.00	.54	.65	.63	.88	.50	.45	1.07	1.44	1.46	1.40	.68	1.02
Manganese Oxide, Mn_3O_4,	.04	.02	.04	.04	.01	.03	.03	.03	.03	.03	.09	.07	.07	.07	.04	.045
Ferric Oxide, Fe_2O_3,	3.05	3.39	3.32	2.62	2.86	3.54	2.41	4.10	3.00	3.92	3.64	4.82	4.82	4.96	3.05	4.02
Alumina, Al_2O_3,	5.50	4.98	5.22	5.45	4.81	4.54	3.67	5.43	4.98	4.26	5.60	5.65	5.90	5.57	4.96	5.22
Phosphorus Pentoxide, P_2O_5,	.169	.105	.133	.082	.112	.093	.076	.07	.148	.098	.175	.128	.139	.139	.135	.107
Sulphur Trioxide, SO_3,	.03	.01	.08	.04	.07	.08	.06	.04	.05	.05	.10	.07	.04	.09	.065	.052
Carbon Dioxide, CO_2,	.03	.015	.025	.015	.035	.03	.03	.035	.05	.025	.06	.035	.05	.01	.038	.027
Volatile Matter,	9.42	3.89	7.64	8.45	7.50	3.56	4.39	4.50	8.98	3.80	8.12	4.32	3.89	3.75	7.67	4.52
Nitrogen,	.203	.058	.136	.052	.178	.045	.089	.037	.193	.040	.169	.068	.052	.049	.161	.05
Total Carbon,	2.16	.329	1.49	.347	2.28	.308	.895	.22	2.35	.353	1.75	.27	.122	.095	1.82	.255
Total Potash	1.11	1.50	1.61	2.00	1.01	1.28	2.09	2.32	1.18	1.79	1.63	2.63	2.99	2.72	1.44	2.15
Total Soda,	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
Total Phosphorus Pentoxide,	.219	.111	.145	.097	.134	.100	.087	.074	.168	.102	.205	.130	.143	.145	.16	.112
Hygroscopic Moisture,	......	......	......	......	......	......	......	......	......	......	1.54	.76	.76	.76	1.54	.76

* According to a system adopted by the State Geological Survey, these figures indicate the exact location.

DUTCHESS LOAM. (SHALEY PHASE.)

Location,	1½ Mi. W. of Newton. 21-35-4-5-5-9		1½ Mi. E. of Libertyville. 22-12-8-1-8		1 Mi. S. E. Unionville. 22-13-1-2		1¼ Mi. S. Stillwater. 21-34-8-4-8-2		Average.	
Depth of Sampling,	0–8″	12–20″	0–8″	12–20″	0–7″	12–20″	0–7″	12–20″		
Soil Number,	43	44	59	60	95	96	121	122	Soil	Sub-soil
Insoluble Matter,	78.36	81.31	79.63	87.98	79.70	82.25	82.61	84.66	80.07	84.05
Soluble Silica, SiO_2,	.06	.02	.06	.04	.08	.08	.05	.03	.062	.042
Potash, K_2O,	.33	.37	.38	.29	.29	.39	.26	.35	.315	.350
Soda, Na_2O,	.05	.21	.05	.04	.08	.07	.05	.09	.057	.102
Lime, CaO,	.08	.04	.11	.09	.12	.07	.12	.00	.107	.05
Magnesia, MgO,	1.09	1.14	.97	1.04	.66	.87	.92	1.00	.916	1.012
Manganese Oxide, Mn_3O_4,	.06	.06	.03	.02	.09	.03	.08	.04	.065	.037
Ferric Oxide, Fe_2O_3,	4.25	4.45	3.88	4.03	3.78	4.46	3.76	4.63	3.917	4.392
Alumina, Al_2O_3,	6.39	6.14	6.04	6.40	5.49	6.03	4.91	5.38	5.707	5.989
Phosphorus Pentoxide, P_2O_5,	.218	.172	.171	.10	.172	.151	.183	.114	.186	.109
Sulphur Trioxide, SO_3,	.05	.05	.05	.04	.06	.06	.08	.08	.06	.0575
Carbon Dioxide, CO_2,	.03	.025	....	.01	.06	.025	.045	.015	.034	.019
Volatile Matter,	8.56	5.58	8.40	5.76	8.86	5.09	7.04	3.64	6.215	5.017
Nitrogen,	.2065	.078	.161	.054	.187	.054	.137	.043	.173	.057
Total Carbon,	2.19	.835	1.65	.244	2.13	7.18	1.54	.198	1.877	.497
Total Potash,	1.58	1.80	1.73	2.04	1.47	1.81	1.94	2.52	1.680	2.042
Total Soda,	....	....	....	....	....	....	....	....	....	....
Total Phosphorus Pentoxide,	.259	.176	.215	.117	.202	.16	.185	.122	.215	.144
Hygroscopic Moisture,	....	....	....	....	....	....	....	....	....	....

DUTCHESS SHALE LOAM.

Location,	1½ Mi. E. of Augusta. 22-21-9-1-2-9		2 Mi. W. of Newton. 21-35-4-2-2-6		5 Mi. N. of Sussex. 22-12-2-6-4-5		2⅔ Mi. W. of Middleville. 21-33-3-9-4-5		2 Mi. S. of Stillwater. 21-34-7-9-4-5		Average.	
Depth of Sampling,	0–7″	12–20″	0–8″	12–20″	0–8″	12–20″	0–7″	12–20″	0–7″	12–20″		
Soil Number,	71	72	75	76	88	87	119	120	179	180	Soil	Sub-soil
Insoluble Matter,	79.13	85.25	74.62	78.51	72.40	77.60	78.14	74.90	75.45	78.90	75.95	79.03
Soluble Silica, SiO_2,	.06	.05	.07	.05	.05	.03	.05	.03	.08	.06	.06	.044
Potash, K_2O,	.25	.28	.31	.40	.56	.60	.24	.36	.35	.29	.34	.39
Soda, Na_2O,	.07	.05	.06	.07	.08	.10	.08	.11	.08	.11	.074	.088
Lime, CaO,	.07	.02	.18	.12	.02	.02	.24	.04	.16	.16	.13	.07
Magnesia, MgO,	.39	.72	1.20	1.32	1.16	1.28	.89	1.50	1.34	1.77	1.00	1.32
Manganese Oxide, Mn_3O_4,	.02	.02	.04	.03	.05	.03	.02	.01	.11	.03	.05	.02
Ferric Oxide, Fe_2O_3,	3.02	2.62	4.98	4.91	5.53	5.58	3.87	6.46	5.05	6.05	4.49	5.12
Alumina, Al_2O_3,	4.52	5.77	6.58	8.13	7.93	8.30	6.67	8.05	7.96	6.78	6.73	7.41
Phosphorus Pentoxide, P_2O_5,	.098	.115	.08	.077	.126	.135	.173	.24	.207	.194	.137	.152
Sulphur Trioxide, SO_3,	.04	.03	.06	.04	.07	.08	.09	.14	....	....	.06	.07
Carbon Dioxide, CO_2,	.047	.02	.065	.025	.065	.035	.05	.035	.04	.015	.053	.026
Volatile Matter,	12.39	5.08	11.63	6.28	12.09	6.56	9.75	7.97	9.42	5.52	11.06	6.28
Nitrogen,	.179	.048	.222	.065	.273	.079	.213	.090	.18	.071	.213	.071
Total Carbon,	1.88	.343	2.70	.645	3.02	.533	2.43	.774	2.10	.368	2.43	.53
Total Potash,	1.21	.81	1.75	1.85	1.56	1.86	1.51	2.77	2.00	3.04	1.606	2.06
Total Soda,	....	....	....	....	....	....	....	....	....	....	....	....
Total Phosphorus Pentoxide,	.100	.117	.106	.084	.157	.146	.192	.247	.23	.195	.157	.158
Hygroscopic Moisture,	....	....	....	....	....	....	....	....	....	....	....	....

DOVER SERIES.

The soils of the Dover series occur in the limestone districts of Kittatinny, Sparta, and Vernon valleys. The series is characterized by the presence of limestone boulders and outcropping of the underlying limestone formation. This gives the surface of much of this series a warty appearance. The soils invariably have a brown surface with a yellow subsoil. The Dover soils have a greater producing power than any of the other series of the area. The types recognized are the loam with a light phase, stony loam, and fine sandy loam.

The following mechanical analyses give the relative differences in texture of this series.

RESULTS OF MECHANICAL ANALYSES OF REPRESENTATIVE SAMPLES OF THE DOVER SERIES.

SOIL TYPE.	Soil Number.	Coarse Gravel. Over 2 mm.	Fine Earth. Und. 2 mm.	Fine Gravel. 2–1 mm.	Coarse Sand. 1–0.5	Medium Sand. 0.5–0.25	Fine Sand. 0.25–0.1	Very Fine Sand. 0.1–0.05	Silt. 0.05–0.005	Clay. 0.005–0.000
		Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Loam, 0–6 in., ..	146	25.0	75.0	5.2	6.6	5.1	13.9	7.6	49.0	12.3
Loam, 12–20 in., .	147	20.6	79.4	3.9	6.3	4.7	11.6	9.3	38.6	25.5
Loam, Light Phase, 0–8 in., .	169	16.4	83.6	4.4	8.7	7.4	18.1	11.4	38.4	11.4
Loam, Light Phase, 12–20 in.,	170	16.8	83.2	4.0	9.1	8.5	20.2	15.1	30.4	12.8
Stony Loam, 0–8 in., ...	73	32.4	67.6	2.11	2.39	2.62	12.02	25.05	35.10	20.14
Stony Loam, 12–20 in., ...	74	31.9	68.1	3.49	3.89	3.81	15.44	24.74	28.46	20.65
Fine Sandy Loam, 0–8 in., ...	101	6.5	93.5	.9	1.1	2.1	17.0	24.3	43.6	10.9
Fine Sandy Loam, 12–20 in., ...	102	6.7	93.3	.5	1.7	2.4	18.4	30.5	35.0	11.4

Dover Loam and Dover Stony Loam.

The Dover soils are regarded as glaciated soils which occur in limestone districts. A large part of the material from which they were formed is supposed to have been derived from limestone. If we may judge from the analyses here reported, the lime has already been largely leached out, for in neither the loam nor the stony loam do we find the average for the soils reaching 0.2%, the amount reported by Hilgard as the average for the soils of the humid regions of the United States. In the loams, the average for the subsoils is slightly higher than for the soils, while in the stony loams the reverse is true. The average for the acid soluble potash in the loams is in the soil 0.203% and in the subsoil 0.448%; the total potash in the soil and subsoil is 2.46% and 2.92% respectively. The soil, both loam and stony loam, contains approximately three times as much magnesia as lime. The total phosphoric acid is, for the soil, 0.134%, and for the subsoil 0.126%, while the nitrogen is 0.145% and 0.048% for the soil and subsoil respectively. The stony loam contains slightly less of the plant food materials—nitrogen, phosphoric acid, potash, and lime—than the loam.

Dover Fine Sandy Loam.

Only one sample of the Dover fine sandy loam is reported. In this sample the percentage of insoluble matter is very nearly the same in both soil and subsoil, the average being about 89%, which is higher than is found in most of the types. The potash content does not differ greatly from that of the Dutchess and Gloucester series. It may be pointed out that the total potash is less in the subsoil than in the soil. The lime present is little more than a trace, while the magnesia also is low. The ratio of lime to magnesia is in the soil about 1 : 12 and in the subsoil 1 : 10. The low nitrogen and carbon indicate a deficiency of organic matter. The phosphoric acid is slightly lower than has been observed in most of the types.

DOVER LOAM.

Location,	¾ Mi. N. of North Church. 22–5–6–7–8–9		Squire's Corners. 21–43–3–1–3–5		2 Mi. N. of Vernon. 22–13–9–3–9–3		Average.	
Depth of Sample,	0″–6″	12″–20″	0″–8″	12″–20″	0″–6″	12″–20″		
Sample Number,	49	50	215	216	146	147	Soil.	Sub-soil.
Insoluble Matter,	88.36	84.03	87.48	85.08	84.96	82.16	86.93	83.75
Soluble Silica, SiO_2,	.04	.04	.04	.03	.07	.05	.05	.04
Potash, K_2O,	.17	.46	.21	.37	.23	.51	.203	.448
Soda, Na_2O,	.08	.07	.04	.09	.09	.14	.07	.10
Lime, CaO,	.14	.14	.09	.06	.16	.57	.13	.259
Magnesia, MgO,	.62	.86	.52	.60	.39	1.10	.51	.85
Manganese Oxide, Mn_3O_4,	.02	.05	.10	.04	.06	.10	.06	.063
Ferric Oxide, Fe_2O_3,	2.38	2.88	2.65	4.43	2.98	4.96	2.67	4.09
Alumina, Al_2O_3,	3.73	6.59	3.41	4.99	2.13	5.11	3.09	5.56
Phosphorus Pentoxide, P_2O_5,	.079	.061	.116	.133	.144	.145	.113	.113
Carbon Dioxide, CO_2,	.015	.025	.025	.015	.035	.370	.025	.136
Volatile Matter,	4.40	4.92	5.29	4.22	8.96	4.75	6.21	4.63
Nitrogen,	.108	.044	.132	.038	.197	.063	.145	.048
Total Carbon,	1.06	.222	1.51	.268	2.05	.632	1.54	.374
Total Potash,	1.77	2.43	2.79	2.64	2.82	3.71	2.46	2.92
Total Soda,	....	....	.29	.62	.91	.96	.60	.79
Total Phosphorus Pentoxide,	.096	.068	.128	.138	.18	.172	.134	.126
Hygroscopic Moisture,	....	....	....	....	2.32	1.51	2.32	1.51

DOVER LOAM. (LIGHT PHASE.)

Location,	⅔ Mi. N. of Hardistonville. 22-22-6-6-9-4		1 Mi. N. W. of Franklin Furnace. 22-22-8-6-6-3		Average.	
Depth of Sample,	0"-8"	12"-20"	0"-8"	12"-20"		
Sample Number,	169	170	171	172	Soil.	Sub-soil.
Insoluble Matter,	87.58	88.69	86.17	85.93	86.87	87.31
Soluble Silica, SiO_2,	.06	.05	.07	.02	.065	.035
Potash, K_2O,	.07	.28	.19	.39	.13	.335
Soda, Na_2O,	.03	.06	.08	.06	.055	.06
Lime, CaO,	.26	.19	.22	.21	.24	.20
Magnesia, MgO,	.68	.84	.54	.90	.61	.87
Manganese Oxide, Mn_3O_4,	.05	.06	.04	.06	.045	.06
Ferric Oxide, Fe_2O_3,	2.62	3.05	3.05	3.93	2.835	3.49
Alumina, Al_2O_3,	3.56	3.92	3.58	4.73	3.570	4.325
Phosphorus Pentoxide, P_2O_5,	.158	.088	.135	.143	.146	.1155
Carbon Dioxide, CO_2,	.035	.02	.035	.015	.035	.0175
Volatile Matter,	4.96	2.71	5.69	3.32	5.32	3.015
Nitrogen,	.115	.026	.153	.136	.138	.083
Total Carbon,	1.38	.278	1.52	.38	1.45	.329
Total Potash,	2.73	2.95	2.78	3.66	2.755	3.31
Total Soda,	.90	1.08	1.06	1.12	.98	1.10
Total Phosphorus Pentoxide,	.169	.098	.167	.145	.168	.1215
Hygroscopic Moisture,	1.19	.93	1.28	1.02	1.235	.975

DOVER STONY LOAM.

Location,	1½ Mi. W. of Monroe Corners. 22–22–7–1–8–8		⅓ Mi. N. of Iliff's Pond. 22–31–5–8–7–8		1½ Mi. S. W. of Stillwater. 21–33–9–6–3–8		Average.	
Depth of Sampling,	0″–8″	12″–20″	0″–8″	12″–20″	0″–4″	12″–20″	Soil.	Sub-soil.
Soil Number,	73	74	81	82	213	214		
Insoluble Matter,	84.61	83.32	87.80	86.03	87.59	82.87	86.667	84.07
Soluble Silica, SiO_2,	.06	.05	.01	.01	.03	.03	.033	.03
Potash, K_2O,	.18	.32	.18	.33	.15	.30	.170	.317
Soda, Na_2O,	.04	.06	.04	.09	.09	.06	.057	.070
Lime, CaO,	.1	.13	.20	.15	.09	.06	.153	.113
Magnesia, MgO,	.62	.87	.45	.78	.46	.70	.510	.787
Manganese Oxide, Mn_3O_4,	.02	.05	....	.03	.01	.035	.015	.038
Ferric Oxide, Fe_2O_3,	2.50	3.03	2.43	3.50	2.05	4.73	2.327	3.753
Alumina, Al_2O_3,	4.12	6.84	4.02	5.16	3.53	6.09	3.890	6.030
Phosphorus Pentoxide, P_2O_5,	.086	.086	.061	.04	.083	.094	.077	.073
Sulphur Trioxide, SO_3,	.03	.04	.05	.04	....	....	.040	.040
Carbon Dioxide, CO_2,	.03	.10	.045	.02	.03	.02	.035	.047
Volatile Matter,	7.60	4.96	4.67	3.72	6.08	4.98	6.117	4.555
Nitrogen,	.103	.041	.077	.028	.156	.039	.112	.036
Total Carbon,	1.13	.346	1.08	.268	2.05	.95	1.420	.521
Total Potash,	1.51	1.92	1.36	1.81	2.49	3.04	1.787	2.257
Total Soda,	....	....	....	....	.50	.94	.500	.940
Total Phosphorus Pentoxide,	.102	.095	.064	.048	.107	.095	.091	.079
Hygroscopic Moisture,	....	....	....	....	....	....	....	....

DOVER FINE SANDY LOAM.

Location,	200 yds. S. E. of Monroe's Corners. 22-22-7-6-9-7	
Depth, of Sampling,	0"-8"	12"-20"
Soil Number,	101	102
Insoluble Matter,	88.84	89.08
Soluble Silica, SiO_2,	.05	.04
Potash, K_2O,	.21	.54
Soda, Na_2O,	.06	.13
Lime, CaO,	.02	.05
Magnesia, MgO,	.25	.50
Manganese Oxide, Mn_3O_4,	.03	.02
Ferric Oxide, Fe_2O_3,	2.28	2.57
Alumina, Al_2O_3,	3.40	4.12
Phosphorus Pentoxide, P_2O_5,	.121	.092
Sulphur Trioxide, SO_3,	.06	.04
Carbon Dioxide, CO_2,	.035	.02
Volatile Matter,	4.48	2.89
Nitrogen,	.097	.024
Total Carbon,	1.02	.251
Total Potash,	1.88	1.18
Total Soda,	....	....
Total Phosphorus Pentoxide,	.137	.168
Hygroscopic Moisture,	....	....

GLOUCESTER SERIES.

The soils of the Gloucester series occur chiefly on the crystalline rocks of the Highlands. They are derived immediately from the mantle of glacial drift, but since this is chiefly local in origin, the soils of this series are all characterized by the presence of materials derived from the underlying gneiss through their mechanical disintegration and chemical decomposition. These soils, as a rule, are sandy and stony. All are more or less characterized by the presence of small mica fragments, which are thoroughly mixed with the soil mass, and in some cases give the soils a slightly greasy feel.

The following types are represented: Rough stony land, loam, stony loam, sandy loam and stony sandy loam.

Mechanical analyses are as follows:

RESULTS OF MECHANICAL ANALYSES OF REPRESENTATIVE SAMPLES OF GLOUCESTER SERIES.

SOIL TYPE.	Soil Number.	Coarse Gravel. Over 2 mm.	Fine Earth. Und. 2 mm.	Fine Gravel. 2–1	Coarse Sand. 1–0.5	Medium Sand. 0.5–0.25	Fine Sand. 0.25–0.1	Very Fine Sand. 0.1–0.05	Silt. 0.05–0.005	Clay. 0.005–0.000
		Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Loam, 0–10 in., .	135	14.8	85.2	3.0	6.7	6.2	14.9	11.1	46.2	11.7
Loam, 12–20 in., .	136	32.6	67.4	5.7	9.6	8.3	17.5	13.9	31.1	13.5
Stony Loam, 0–7 in., ...	154	15.1	84.9	4.1	4.9	4.5	14.3	11.7	46.5	13.8
Stony Loam, 12–20 in., ...	155	31.2	68.8	2.7	4.3	4.2	15.4	15.0	44.9	13.3
Stony Sandy Loam, 0–7 in., .	131	27.7	77.5	4.0	10.4	9.3	21.2	12.6	32.1	10.3
Stony Sandy Loam, 12–20 in.,	132	22.5	72.3	5.2	11.4	9.5	19.6	14.6	30.2	9.3
Sandy Loam, 0–8 in., ...	41	15.7	84.3	9.31	11.1	7.64	21.87	12.99	26.37	10.85
Sandy Loam, 12–20 in., ...	42	13.4	86.4	11.1	12.47	8.68	22.68	13.14	22.46	10.17

In this series analyses have been made of sixteen soils and sixteen subsoils, as follows: five of loam, three of sandy loam, four of stony loam and four of stony sandy loam. The four types are quite similar in chemical composition, though there are some important differences between this series and the Dutchess series.

The soils and subsoils of the Gloucester series are higher in insoluble matter, lime and potash than those of the Dutchess series. On first thought the higher percentage of insoluble matter might seem to indicate less plant food. This does not, however, seem to be the case with the Gloucester series. There is more lime and potash than there is in the Dutchess series and nearly as much phosphoric acid and nitrogen, but there is less iron and alumina and total carbon.

The average amount of total potash in the soil for the four types is 2.60%, while the amount in the subsoil is even greater, The average amount of acid soluble potash in the soils is 0.17%, or about 1/15 of the total, while in the subsoil it is 0.245%.

The average amount of lime in the soil is 0.31% and the magnesia 0.54%, which gives a ratio of lime to magnesia of 1 : 1.74.

The ratio in the loam is 1 : 2.46, in the sandy loam 1 : 1.15, in the stony loam 1 : 3, and in the stony sandy loam 1 : 1.23. It may be of interest to note that in this series the ratio nowhere exceeds 1 : 3.

The average amount of total carbon in the four types is 1.72%, which is about 1/8 less than the amount found in the Dutchess series. It may be pointed out that the sandy loam, which is the lowest in nitrogen, is also lowest in total carbon, while the stony loam, which is the highest in nitrogen, is also highest in total carbon. Since the carbon is practically all of organic origin (there being scarcely more than a trace of carbon dioxide present), there is, in an 8-inch acre of this soil, over 40,000 pounds of organic carbon. This represents organic matter which, under proper methods, may be looked to to supply nitrogen and humus. Taking the averages, there is in this series invariably more alumina than iron, and, with one exception, more of both in the subsoil than in the soil.

GLOUCESTER LOAM.

Location,	1 Mi. E. of Mulford. 22-31-6-6-8-4		2 Mi. N. E. of Sparta. 22-32-5-6-3-2		½ Mi. S. of Glenwood. 22-13-6-8-1-2		4¾ Mi. E. of Vernon. 22-14-9-7-9-7		1 Mi. N. E. of Monroe Corners. 22-22-8-5-5-1		Average.	
Depth of Sampling,	0–8″	12–20″	0–10″	12–20″	0–8″	12–20″	0–8″	12–20″	0–10″	12–20″		
Soil Number,	66	67	135	136	152	153	156	157	165	166	Soil	Sub-soil
Insoluble Matter,	79.62	80.35	85.23	88.27	86.37	85.99	83.96	86.77	87.57	90.33	84.55	86.34
Soluble Silica, SiO_2,	.05	.06	.04	.04	.07	.03	.03	.03	.07	.06	.05	.04
Potash, K_2O,	.17	.34	.19	.26	.26	.39	.29	.44	.14	.18	.21	.32
Soda, Na_2O,	.06	.06	.12	.19	.08	.07	.08	.09	.07	.06	.08	.09
Lime, CaO,	.29	.32	.38	.33	.19	.18	.05	.04	.40	.18	.26	.21
Magnesia, MgO,	.71	1.01	.62	1.01	.54	.84	.79	1.04	.54	.47	.64	.87
Manganese Oxide, Mn_3O_4,	.03	.02	.10	.10	.10	.02	.03	.01	.02	.01	.06	.03
Ferric Oxide, Fe_2O_3,	2.57	3.12	2.91	3.32	2.35	2.35	2.80	3.72	1.86	2.85	2.50	3.07
Alumina, Al_2O_3,	5.13	7.14	4.07	3.68	3.83	6.18	4.49	4.26	3.59	3.07	4.22	4.86
Phosphorus Pentoxide, P_2O_5,	.108	.078	.083	.064	.118	.073	.112	.073	.124	.10	.109	.078
Sulphur Trioxide, SO_3,	.06	.05	.06	.06	....	....	....	....	....	....	.06	.05
Carbon Dioxide, CO_2,	.02	.015	.03	.017	.065	.02	.06	.02	.02	.01	.04	.016
Volatile Matter,	10.87	7.27	6.63	3.25	5.93	3.75	7.03	3.28	5.89	2.73	7.27	4.06
Nitrogen,	.121	.031	.152	.061	.149	.046	.185	.062	.141	.046	.150	.049
Total Carbon,	1.39	.238	1.06	.513	1.73	.30	1.96	.306	1.81	.431	1.59	.358
Total Potash,	2.64	3.55	2.88	3.48	1.90	2.30	2.48	2.28	3.00	2.95	2.58	2.91
Total Soda,	....	....	1.48	1.21	1.07	1.02	2.02	1.08	1.15	1.25	1.43	1.14
Total Phosphorus Pentoxide,	.113	.084	.108	.079	.14	.079	.138	.091	.144	.113	.129	.089
Hygroscopic Moisture,	....	....	1.29	1.23	1.64	1.44	1.88	.80	1.38	.65	1.55	1.03

GLOUCESTER SANDY LOAM.

Location,	2 Mi. S. E. of Iliff's Pond. 22-31-9-8-1-9		3¼ Mi. S. of Sparta. 22-41-3-6-9-6		1½ Mi. S. of Sparta. 22-32-8-4-8-1		Average.	
Depth of Sampling,	0″–6″	12″–20″	0″–8″	12″–20″	0″–8″	12″–20″	Soil.	Sub-soil.
Soil Number,	41	42	123	124	137	144		
Insoluble Matter,	84.43	88.66	85.09	86.70	84.55	86.85	84.60	87.40
Soluble Silica, SiO_2,	.03	.04	.03	.01	.05	.23	.03	.09
Potash, K_2O,	.14	.19	.13	.18	.16	.28	.14	.22
Soda, Na_2O,	.11	.17	.11	.05	.09	.09	.10	.10
Lime, CaO,	.59	1.21	.37	.51	.39	.35	.45	.69
Magnesia, MgO,	.59	.69	.44	.62	.53	.71	.52	.67
Manganese Oxide, Mn_3O_4,	.05	.03	.09	.05	.06	.04	.07	.04
Ferric Oxide, Fe_2O_3,	3.27	3.17	3.98	5.07	4.03	4.82	3.76	4.35
Alumina, Al_2O_3,	3.98	3.38	3.55	3.56	3.83	3.83	3.79	3.59
Phosphorus Pentoxide, P_2O_5,	.168	.104	.156	.107	.145	.11	.156	.107
Sulphur Trioxide, SO_3,	.05	.04	.00	.08	....	....	.045	.085
Carbon Dioxide, CO_2,	.06	....	.10	.04	.065	.02	.075	.05
Volatile Matter,	6.41	2.06	6.03	3.07	6.01	3.13	6.15	2.75
Nitrogen,	.137	.028	.139	.030	.118	.032	.131	.03
Total Carbon,	1.84	.285	1.07	.217	1.01	.22	1.31	.24
Total Potash,	2.94	3.08	3.17	3.14	3.08	3.24	3.06	2.89
Total Soda,	....	....	....	....	1.86	1.45	.186	1.45
Total Phosphorus Pentoxide,	.187	.103	.161	.121	.177	.108	.175	.11
Hygroscopic Moisture,	....	....	1.23	.97	1.99	.78	1.61	.87

GLOUCESTER STONY LOAM.

Location,	1½ Mi. W. of Sparta. 22-31-6-9-9-9		3½ Mi. E. of Vernon. 22-24-2-1-5-4		⅓ Mi. N. of Glenwood. 22-13-6-5-1-1		1½ Mi. S. of Vernon. 22-23-3-7-3-3		Average.	
Depth of Sampling,	0–7"	12–20"	0–8"	12–20"	0–7"	12–20"	0–7"	12–20"	Soil	Sub-soil
Soil Number,	142	143	150	151	155	154	158	159		
Insoluble Matter,	82.59	85.47	79.62	85.38	89.15	89.65	85.40	86.08	84.19	86.64
Soluble Silica, SiO_2,	.16	.11	.05	.06	.03	.04	.04	.02	.07	.057
Potash, K_2O,	.18	.26	.28	.33	.17	.17	.19	.27	.205	.257
Soda, Na_2O,	.07	.06	.21	.25	.07	.06	.08	.12	.11	.12
Lime, CaO,	.40	.41	.08	.06	.05	Trace	.23	.16	.19	.157
Magnesia, MgO,	.78	.95	.53	.71	.48	.69	.48	.69	.57	.76
Manganese Oxide, Mn_3O_4,	.07	.04	.02	.045	.02	.01	.01	.04	.03	.034
Ferric Oxide, Fe_2O_3,	3.57	4.41	2.98	2.52	2.03	1.61	3.39	4.35	2.99	3.22
Alumina, Al_2O_3,	5.17	4.59	4.94	5.91	2.62	5.09	3.33	3.93	4.01	4.88
Phosphorus Pentoxide, P_2O_5,	.166	.145	.142	.122	.078	.063	.118	.122	.126	.113
Sulphur Trioxide, SO_3,	......	......	......	......	......	......	......	......	......	......
Carbon Dioxide, CO_2,	.05	.015	.065	.025	.05	.02	.05	.035	.054	.024
Volatile Matter,	7.33	3.79	10.82	4.76	5.15	2.73	6.45	4.11	7.44	3.85
Nitrogen,	.164	.036	.223	.094	.143	.033	.165	.062	.174	.056
Total Carbon,	1.89	.307	3.61	.775	1.60	.274	1.97	.68	2.27	.509
Total Potash,	2.48	2.89	1.72	1.90	1.72	2.09	2.99	3.57	2.22	2.61
Total Soda,	1.06	1.14	.87	.97	1.56	1.61	1.61	1.56	1.27	1.32
Total Phosphorus Pentoxide,	.181	.144	.167	.132	.095	.095	.13	.141	.143	.128
Hygroscopic Moisture,	1.67	1.05	2.88	1.55	1.32	.79	1.41	1.11	1.82	1.12

GLOUCESTER STONY SANDY LOAM.

Location,	1 Mi. S. of Sparta. 22-32-7-6-5-2		2¼ Mi. S. W. Sparta. 22-32-7-8-7-4		3 Mi. E. of Sparta. 22-32-6-9-2-9		3⅓ Mi. W. Vernon. 22-13-7-8-2-5		Average.	
Depth of Sampling,	0–7″	12–20″	0–7″	12–20″	0–8″	12–20″	0–8″	12–20″	Soil	Sub-soil
Soil Number,	131	132	133	134	138	139	160	161		
Insoluble Matter,	87.29	89.34	85.66	87.19	77.11	83.03	86.38	89.03	84.11	87.15
Soluble Silica, SiO_2,	.04	.03	.05	.05	.04	.03	.03	.03	.04	.035
Potash, K_2O,	1.10	.12	.14	.19	.16	.23	.14	.18	.13	.18
Soda, Na_2O,	.11	.14	.15	.13	.08	.10	.11	.10	.11	.12
Lime, CaO,	.33	.30	.32	.41	.49	.56	.24	.25	.35	.38
Magnesia, MgO,	.41	.43	.41	.68	.56	.64	.32	.34	.43	.52
Manganese Oxide, Mn_3O_4,	.03	.03	.06	.04	.12	.07	.02	.01	.06	.04
Ferric Oxide, Fe_2O_3,	2.69	3.05	3.71	4.18	6.20	6.67	2.11	1.64	3.68	3.88
Alumina, Al_2O_3,	3.14	3.31	3.72	4.37	5.40	4.89	4.54	4.73	4.20	4.32
Phosphorus Pentoxide, P_2O_5,	.099	.095	.120	.101	.285	.163	.104	.112	.152	.118
Sulphur Trioxide, SO_3,	.07	.06	.06	.06	....	....	....	....	.06	.06
Carbon Dioxide, CO_2,	.035	.085	.035	.01	.08	.05	.06	.03	.05	.044
Volatile Matter,	5.64	3.06	5.32	2.54	9.21	3.47	6.29	3.63	6.61	3.18
Nitrogen,	.12	.045	.097	.023	.196	.046	.143	.055	.139	.042
Total Carbon,	1.31	.36	1.15	.219	2.71	.451	1.73	.556	1.72	.40
Total Potash,	2.28	2.33	2.92	2.68	2.44	3.08	2.48	2.60	2.53	2.67
Total Soda,	....	....	....	....	1.67	1.00	1.98	2.22	1.82	1.61
Total Phosphorus Pentoxide,	.119	.104	.131	.112	.321	.166	.124	.124	.174	.126
Hygroscopic Moisture,	.86	.80	1.17	.76	2.68	1.25	1.48	1.22	1.55	1.00

LACKAWANNA SERIES.

The soils of the Lackawanna series as they occur in the area overlie the red shales of the Highfalls formation, which are found on the west slope of Kittatinny Mountain. They are characterized by their red color, and are locally called "red shell (shale) lands." Only two types of this series were encountered in the present area. They are the loam and stony loam. The mechanical analyses of the Lackawanna loam are shown in the table, p. 49, while the chemical composition of the type is given in connection with the Wallpack series (p. 52).

RESULTS OF MECHANICAL ANALYSES OF REPRESENTATIVE SAMPLES OF THE LACKAWANNA LOAM.

SOIL TYPE.	Soil Number.	Coarse Gravel. Over 2 mm.	Fine Earth.	Fine Gravel. 2–1	Coarse Sand. 1–0.5	Medium Sand. 0.5–0.25	Fine Sand. 0.25–0.1	Very Fine Sand. 0.1–0.05	Silt. 0.05–0.005	Clay. 0.005–0.000
		Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Loam, 0–9 in., ...	199	48.	52.	7.16	3.49	4.26	9.44	13.96	46.33	15.36
Loam, 12–20 in., .	200	33.	67.	7.31	3.75	4.37	10.13	14.36	45.23	14.85

MECHANICAL ANALYSES OF REPRESENTATIVE SAMPLES OF THE WALLPACK SERIES.

SOIL TYPE.	Soil Number.	Coarse Gravel. Over 2 mm.	Fine Earth.	Fine Gravel. 2–1	Coarse Sand. 1–0.5	Medium Sand. 0.5–0.25	Fine Sand. 0.25–0.1	Very Fine Sand. 0.1–0.05	Silt. 0.05–0.005	Clay. 0.005–0.000
		Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Silt Loam, 0–7 in., ...	183	20.	80.	6.4	4.9	5.23	8.72	9.96	45.71	19.05
Silt Loam, 12–20 in., ...	184	10.8	89.2	6.6	4.5	4.48	7.06	10.85	42.54	23.94
Shale Loam, 0–7 in., ...	207	49.	51.	11.7	3.87	2.23	2.23	2.53	50.07	27.4
Shale Loam, 12–20 in., ...	208	64.	36.	13.3	7.55	4.16	3.06	2.00	31.78	38.12

The discussion of the chemical composition of the type is found in connection with the Wallpack series.

WALLPACK SERIES.

The Wallpack series is found exclusively on the Wallpack Ridge west of Kittatinny Mountain. This series overlies the various limy shales and limestones of this region. It is distinguished from the Dover series by the cherty character of the rock fragments and varying physical characteristics.

Four types are represented, a silt loam with a heavy subsoil phase, fine sandy loam, shale loam and stony loam.

The mechanical analyses appear on page 49.

Wallpack Silt Loam. Wallpack Silt Loam, Heavy Subsoil Phase. Lackawanna Loam.

The samples representing these three types are so similar in chemical composition that it seems proper to discuss them together. The amount of insoluble matter is higher than in the Dutchess, Gloucester or Hoosic series, and corresponds more nearly to the Dover series. Both the acid-soluble and total potash are somewhat lower than in the Dutchess, Gloucester or Hoosic series. With the exception of one sample of the Wallpack heavy silt loam, they are all deficient in lime—only a trace being reported in most cases. This is hardly to be expected in the Wallpack silt loam, since it is underlain by a limestone formation. It is, however, only another indication of the ease with which the lime is leached out of soils, even those that originally contained a large amount of lime. In most cases the magnesia ranges from 0.4 to 0.6%, and, comparing this with the small amount of lime that is present, it is at once seen that the magnesia is decidedly in excess. Of the three samples the Lackawanna loam is lowest in phosphoric acid, and the Wallpack loam, heavy subsoil phase, is the highest. There appears to be a wider difference in the amount of phosphoric acid found in the soil and subsoil than is usually the case in the

loam soils of the area. In the majority of the cases represented here there is little more than a trace of carbon dioxide, which indicates that practically all of the carbon is of organic origin. The average amount of nitrogen in the soil is about 0.14% and in the subsoil about 0.04%. In some respects these types chemically resemble the Chenango series, though they are richer in nitrogen than the Chenango soils.

LACKAWANNA LOAM.

Location,	½ Mi. E. Wallpack Centre. 21–24–4–3–9–8		1 Mi. S. E. Hainesville. 21–15–4–7–3–3		Average.	
Depth of Sample,	0″–9″	12″–20″	0″–7″	12″–20″		
Sample Number,	199	200	205	206	Soil.	Sub-soil.
Insoluble Matter,	84.83	87.56	89.39	91.46	87.11	89.51
Soluble Silica, SiO_2,	.05	.08	.07	.03	.055	.055
Potash, K_2O,	.28	.31	.22	.34	.25	.325
Soda, Na_2O,	.045	.03	.07	.06	.057	.045
Lime, CaO,	TRACE	TRACE	....	.02	TRACE	.01
Magnesia, MgO,	.57	.60	.33	.48	.45	.54
Manganese Oxide, Mn_3O_4,	.045	.04	.04	TRACE	.042	.02
Ferric Oxide, Fe_2O_3,	2.39	2.84	1.66	2.32	2.02	2.58
Alumina, Al_2O_3,	4.24	4.38	3.40	2.95	3.82	3.66
Phosphorus Pentoxide, P_2O_5,	.123	.097	.134	.07	.128	.083
Carbon Dioxide, CO_2,	.015	.01	.005	.01	.01	.01
Volatile Matter,	7.27	4.09	5.06	2.31	6.16	3.2
Nitrogen,	.172	.049	.097	.025	.134	.037
Total Carbon,	2.10	.49	1.451	.213	1.775	.351
Total Potash,	1.07	1.21	.80	1.17	.935	1.19
Total Soda,	.50	.48	.36	.36	.43	.42
Total Phosphorus Pentoxide,	.149	.121	.136	.073	.142	.097

WALLPACK SILT LOAM.

Location,	½ Mi. W. of Layton. 21–14–8–5–2–3		2 Mi. N. W. Layton. 21–14–8–2–3–5		Average.	
Depth of Sample,	0″–7″	12″–20″	0″–7″	12″–20″		
Sample Number,	183	184	211	212	Soil.	Sub-soil.
Insoluble Matter,	86.31	87.82	87.98	90.46	87.14	89.14
Soluble Silica, SiO_2,	.07	.05	.06	.03	.065	.04
Potash, K_2O,	.12	.31	.18	.29	.15	.30
Soda, Na_2O,	.08	.07	.06	.07	.07	.07
Lime, CaO,	.04	.06	TRACE	TRACE	.02	.03
Magnesia, MgO,	.76	.97	.43	.54	.59	.75
Manganese Oxide, Mn_3O_4,	.015	.035	.03	.015	.022	.025
Ferric Oxide, Fe_2O_3,	2.72	3.21	1.95	2.50	2.33	2.85
Alumina, Al_2O_3,	3.80	4.49	3.14	3.57	3.47	4.03
Phosphorus Pentoxide, P_2O_5,	.119	.06	.155	.064	.137	.062
Carbon Dioxide, CO_2,	.04	.01	.01	.005	.025	.007
Volatile Matter,	5.91	2.98	6.25	2.66	6.08	2.82
Nitrogen,	.146	.038	.144	.04	.145	.039
Total Carbon,	1.62	.28	1.95	.341	1.785	.31
Total Potash,	1.16	1.57	.74	1.26	.95	1.415
Total Soda,	.54	.61	.36	.39	.45	.50
Total Phosphorus Pentoxide,	.127	.075	.198	.086	.162	.08

WALLPACK SILT LOAM. (HEAVY SUBSOIL PHASE.)

Location,	½ Mi. N. Bevans. 21–14–8–8–8–7		2 Mi. N. Layton. 21–14–6–8–1–5		Average.	
Depth of Sample,	0″–8″	12″–20″	0″–7″	12″–20″		
Sample Number,	185	186	209	210	Soil.	Sub-soil
Insoluble Matter,	86.75	90.33	88.03	90.06	87.39	90.19
Soluble Silica, SiO_2,	.08	.06	.05	.01	.065	.035
Potash, K_2O,	.19	.15	.18	.25	.185	.20
Soda, Na_2O,	.05	.07	.06	.044	.055	.057
Lime, CaO,	.22	.03	.05	TRACE	.135	.015
Magnesia, MgO,	.42	.58	.42	.57	.42	.575
Manganese Oxide, Mn_3O_4,	.03	.015	TRACE	.015	.015	.015
Ferric Oxide, Fe_2O_3,	2.03	2.50	2.00	2.70	2.03	2.55
Alumina, Al_2O_3,	3.65	3.31	3.25	3.39	3.45	3.35
Phosphorus Pentoxide, P_2O_5,	.202	.071	.151	.097	.176	.084
Carbon Dioxide, CO_2,	.04	.01	.02	.005	.03	.007
Volatile Matter,	6.55	2.88	5.78	2.96	6.16	2.92
Nitrogen,	.153	.042	.135	.041	.144	.041
Total Carbon,	1.78	.293	1.71	.273	1.745	.283
Total Potash,	.97	1.19	.80	1.31	.885	1.25
Total Soda,	.45	.47	.40	.36	.42	.41
Total Phosphorus Pentoxide,	.222	.088	.173	.106	.197	.097

Wallpack Shale Loam.

This type is represented by only one soil and one subsoil. It is fairly well supplied with the fertilizing elements—nitrogen, phosphoric acid, potash and lime. The percentage of nitrogen is unusually high, being equivalent to more than 5,000 pounds per 8-inch acre. The subsoil also contains more nitrogen than the majority of samples found in this region. The ratio of lime to magnesia in the soil is approximately 1 : 3. Such a soil will require a minimum of commercial fertlizers if good cultural methods are adopted.

WALLPACK SHALE LOAM.

Location,	1 Mi. S. W. Hainesville. 21–14–6–5–9–1	
Depth of Sample,	0″–7″	12″–20″
Sample Number,	207	208
Insoluble Matter,	82.62	82.72
Soluble Silica, SiO_2,	.07	.06
Potash, K_2O,	.27	.38
Soda, Na_2O,	.07	.05
Lime, CaO,	.25	.11
Magnesia, MgO,	.74	1.04
Manganese Oxide, Mn_3O_4,	.035	.03
Ferric Oxide, Fe_2O_3,	2.12	3.85
Alumina, Al_2O_3,	4.79	5.63
Phosphorus Pentoxide, P_2O_5,	.148	.192
Carbon Dioxide, CO_2,	.050	.035
Volatile Matter,	8.40	5.78
Nitrogen,	.226	.106
Total Carbon,	2.76	.891
Total Potash,	1.36	2.20
Total Soda,	.52	.43
Total Phosphorus Pentoxide,	.186	.213

HOOSIC SERIES.

The soils of the Hoosic series occur on sand and gravel deposits made by glacial waters during the closing stages of the ice period. Both soil and subsoil are characterized by rounded,

water-worn pebbles and the absence of boulders, except in very rare instances. In distribution they are not limited in elevation, although found more frequently along valley bottoms than on hilltops, and they occur in all parts of the district. The members of the series are the Hoosic loam, Hoosic sandy loam and Hoosic gravelly loam.

RESULTS OF MECHANICAL ANALYSES OF REPRESENTATIVE SAMPLES OF THE HOOSIC SERIES.

SOIL TYPE.	Soil Number.	Coarse Gravel. Over 2 mm.	Fine Earth. Und. 2 mm.	Fine Gravel. 2–1	Coarse Sand. 1–0.5	Medium Sand. 0.5–0.25	Fine Sand. 0.25–0.1	Very Fine Sand. 0.1–0.05	Silt. 0.05–0.005	Clay. 0.005–0.000
		Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Loam, 0–8 in., ..	79	15.99	84.01	4.75	4.42	2.77	9.10	22.46	38.66	18.91
Loam, 12–20 in., .	80	34.1	65.9	5.22	4.88	3.0	9.90	22.49	34.09	19.90
Gravelly Loam, 0–7 in., ...	91	30.5	69.5	4.9	6.5	4.4	13.6	11.9	42.6	15.2
Gravelly Loam, 12–20 in., ...	92	40.8	59.2	7.0	11.4	7.4	18.2	14.8	27.4	12.8
Sandy Loam, 0–6 in., ...	45	7.21	92.79	5.39	8.72	8.07	24.40	11.02	27.34	15.80
Sandy Loam, 12–20 in., ...	46	47.9	52.1	18.06	22.34	12.18	15.98	5.69	16.12	11.68

Hoosic Loam.

This type is represented by four samples of soil and four of subsoil. The acid-soluble potash in the soil is 0.25% and in the subsoil 0.41%. The total potash in the soil and subsoil is 1.79% and 2.39% respectively. The average amount of lime in the soil is 0.19%, which is practically the amount named by Hilgard as the average for the soils of the humid region of the United States. The average for the total phosphoric acid in the soils is 0.196 and in the subsoils 0.14%, while the nitrogen in the soils is 0.17% and in the subsoils 0.05%.

From the above figures it is seen that these soils are fairly well supplied with nitrogen, phosphoric acid, potash and lime—enough for many crops provided they can be made available. Thorough cultivation and the more general use of green manure crops will help to unlock this stored-up plant food.

Hoosic Sandy Loam.

This type is very similar in chemical composition to the loams of this series. From an examination of the two tables it is seen that the sandy loam does not contain quite as much of the fertilizing constituents as the loam, although it could not be considered greatly deficient in any of these materials. With good cultural methods and the use of green manures the productiveness of these soils can be distinctly increased.

Hoosic Gravelly Loam.

This type is represented by seven samples of soil and subsoil. The average figures for these seven samples, both soils and subsoils, are very similar to the average for the four samples of Hoosic loam. Indeed, from a chemical standpoint a separation could hardly be made. From the mechanical standpoint, however, the gravelly loam contains a higher percentage of fine gravel and a lower percentage of clay. This also is a soil which with proper treatment can be brought into a good state of productiveness.

HOOSIC LOAM.

Location,	½ Mi. W. of Baleville. 22-21-7-7-4-8		1 Mi. S. E. of Augusta. 22-21-8-2-8-9		1½ Mi. W. Hamburg. 22-22-9-2-1-4		½ Mi. N. Layton. 21-14-9-2-7-7		Average.	
									Soil	Sub-soil
Depth of Sampling,	0–8″	12–20″	0–8″	12–20″	0–8″	12–20″	0–7″	12–20″		
Soil Number,	79	80	83	84	167	168	203	204		
Insoluble Matter,	82.97	85.19	81.40	79.94	84.83	78.78	82.57	86.84	82.94	82.69
Soluble Silica, SiO_2,	.04	.04	.02	.02	.02	.07	.07	.05	.04	.045
Potash, K_2O,	.21	.33	.31	.48	.24	.50	.23	.35	.247	.415
Soda, Na_2O,	.04	.06	.07	.14	.08	.12	.09	.08	.07	.10
Lime, CaO,	.23	.09	.25	.11	.21	.23	.08	.02	.192	.112
Magnesia, MgO,	.66	.71	.76	.92	.54	1.41	.59	.77	.64	.95
Manganese Oxide, Mn_3O_4,	.06	.02	.04	.04	.05	.07	.11	.10	.065	.057
Ferric Oxide, Fe_2O_3,	3.15	3.57	3.73	5.03	3.57	4.95	2.15	2.73	3.15	4.07
Alumina, Al_2O_3,	5.14	5.35	5.55	7.20	4.15	8.21	4.95	5.21	4.95	6.49
Phosphorus Pentoxide, P_2O_5,	.065	.088	.135	.125	.124	.185	.38	.13	.176	.132
Sulphur Trioxide, SO_3,	.07	.06	.08	.05	....	....	....	....	.075	.055
Carbon Dioxide, CO_2,	.07	.015	.055	.03	.04	.03	.025	.015	.047	.022
Volatile Matter,	7.53	4.27	7.52	5.62	5.77	5.13	8.93	4.02	7.44	4.76
Nitrogen,	.168	.045	.173	.066	.131	.056	.211	.047	.171	.053
Total Carbon,	2.00	.403	1.97	.557	1.65	.466	2.68	.393	2.075	.455
Total Potash,	1.19	1.75	1.60	1.49	3.36	5.04	1.00	1.29	1.79	2.39
Total Soda,	....	....	....	....	.93	.79	.49	.48	.71	.63
Total Phosphorus Pentoxide,	.096	.093	.154	.138	.149	.186	.385	.13	.196	.139
Hygroscopic Moisture,	....	....	....	....	....	....	....	....	....	....

Hoosic Sandy Loam.

Location,	¼ Mi. East of Augusta. 22-21-8-1-6-8		1½ Mi. N. of Sussex. 22-12-6-8-9-1		15 Rods East of Mulford. 22-31-5-6-9-7		2 Mi. N. W. of Lafayette. 22-21-8-8-2-8		Average.	
Depth of Sampling,	0–6″	12–20″	0–8″	12–20″	0–8″	12–20″	0–7″	12–20″		
Soil Number,	45	46	61	62	78	77	89	90	Soil	Sub-soil
Insoluble Matter,	84.58	83.48	79.88	82.28	87.41	85.51	84.97	86.06	84.21	84.33
Soluble Silica, SiO_2,	.05	.05	.06	.06	.04	.04	.04	.04	.05	.05
Potash, K_2O,	.32	.52	.32	.45	.23	.35	.30	.32	.29	.41
Soda, Na_2O,	.11	.08	.06	.05	.06	.11	.06	.08	.07	.08
Lime, CaO,	.17	.06	.17	.29	.20	.18	.15	.06	.17	.15
Magnesia, MgO,	.68	1.13	.82	1.07	.64	1.06	.72	.89	.71	1.04
Manganese Oxide, Mn_3O_4,	.09	.04	.09	.03	03	.03	.04	.03	.06	.03
Ferric Oxide, Fe_2O_3,	2.81	3.93	3.75	3.91	3.02	4.47	3.71	3.25	3.32	3.89
Alumina, Al_2O_3,	5.04	6.29	5.68	6.71	4.07	4.86	3.62	5.15	4.60	5.75
Phosphorus Pentoxide, P_2O_5,	.154	.145	.189	.192	.088	.085	.147	.135	.144	.139
Sulphur Trioxide, SO_3,	.08	.06	.04	.07	.06	.07	.06	.05	.06	.06
Carbon Dioxide, CO_2,	.03	.01	.045	.005	.035	.017	.05	.035	.04	.017
Volatile Matter,	6.03	3.97	6.07	5.02	4.29	3.28	6.20	3.75	6.40	4.00
Nitrogen,	.128	.055	.195	.056	.079	.030	.119	.037	.13	.044
Total Carbon,	1.30	.36	1.45	.399	1.08	.205	1.31	.241	1.28	.30
Total Potash,	1.75	2.08	1.10	1.93	2.09	1.95	2.33	2.74	1.82	2.18
Total Soda,	....	....	....	....	....	....	....	....	....	....
Total Phosphorus Pentoxide,	.183	.160	.213	.193	.090	.090	.168	.139	.163	.145
Hygroscopic Moisture,	....	....	....	....	....	....	....	....	....	....

HOOSIC GRAVELLY LOAM.

Location,	½ Mi. E. of Branchville. 22-21-4-9-6-7		1½ Mi. N. E. of Sussex. 22-12-9-3-7-7		¼ Mi. S. E. of Papakating. 22-21-6-3-8-4		1¼ Mi. W. of Lafayette. 22-31-2-3-4-1		3½ Mi. N. of Sparta. 22-32-1-6-4-2		1 Mi. N. W. of Vernon. 22-13-9-4-9-1		Layton. 21-14-9-4-6-8		Average.	
Depth of Sampling,	0–8″	12–20″	0–8″	12–20″	0–8″	12–20″	0–7″	12–20″	0–8″	12–20″	0–8″	12–20″	0–7½″	12–20″	Soil	Sub-soil
Soil Number,	51	52	55	56	69	70	91	92	140	141	148	149	201	202		
Insoluble Matter,	80.19	82.48	79.06	83.54	81.15	85.59	82.12	83.90	82.52	82.64	85.94	83.38	83.55	86.17	82.08	83.96
Soluble Silica, SiO_2,	.03	.03	.05	.05	.09	.07	.07	.08	.05	.09	.07	.03	.05	.06	.06	.06
Potash, K_2O,	.35	.40	.47	.48	.36	.38	.36	.42	.25	.45	.34	.48	.30	.37	.347	.426
Soda, Na_2O,	.05	.05	.12	.06	.06	.05	.06	.08	.07	.07	.08	.54	.12	.05	.08	.13
Lime, CaO,	.14	.09	.14	.06	.02	.05	.09	.03	.23	.14	.27	1.47	.08	Trace	.14	.26
Magnesia, MgO,	.81	.85	1.11	1.18	.82	1.03	.93	1.07	.79	1.29	.81	1.53	.65	.97	.84	1.13
Manganese Oxide, Mn_3O_4,	.03	.06	.05	.03	.05	.03	.03	.04	.12	.04	.09	.03	.08	.07	.06	.04
Ferric Oxide, Fe_2O_3,	3.42	3.34	4.35	3.93	4.25	2.93	3.21	2.64	3.56	5.41	3.31	3.50	2.52	3.18	3.52	3.56
Alumina, Al_2O_3,	5.53	6.78	5.55	6.16	5.16	5.84	5.70	6.74	4.89	5.45	3.69	4.54	4.71	4.83	4.75	5.76
Phosphorus Pentoxide, P_2O_5,	.235	.185	.214	.179	.094	.093	.136	.120	.203	.125	.13	.145	.175	.094	.17	.134
Sulphur Trioxide, SO_3,	.10	.09	.04	.02	.03	.02	.13	.05	......	......	......	......	......	......	.07	.04
Carbon Dioxide, CO_2,	.035	.025	.03	.02	.015	.03	.055	.025	.05	.01	.05	.109	.035	.01	.038	.033
Volatile Matter,	9.21	5.54	9.02	4.44	7.52	3.70	7.07	5.02	7.16	4.72	5.12	4.46	8.00	4.36	7.58	4.60
Nitrogen,	.206	.079	.225	.066	.144	.04	.149	.045	.180	.051	.138	.037	.195	.056	.177	.053
Total Carbon,	2.23	.548	2.08	.477	1.46	.204	1.55	.316	2.47	.389	1.41	.72	2.63	.58	1.98	.462
Total Potash,	1.24	1.73	1.86	1.81	1.69	2.16	1.55	1.77	3.18	4.16	2.36	2.48	1.13	1.30	1.858	2.201
Total Soda,	......	......	......	......	......	......	......	......	2.00	.44	.94	1.53	.86	.35	1.27	.77
Total Phosphorus Pentoxide,	.251	.193	.236	.199	.113	.101	.150	.126	.215	.126	.167	.147	.205	.111	.191	.143
Hygroscopic Moisture,	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......

Fox Gravelly Loam.

This soil, like those of the Hoosic series, is derived from stratified material but occurs in a limestone section. A large part of the material making up the soil and subsoil is limestone and the soil consequently has a higher agricultural value.

The mechanical analysis is as follows:

SOIL TYPE.	Soil Number.	Coarse Gravel. Over 2 mm.	Fine Earth. Und. 2 mm.	Fine Gravel. 2–1	Coarse Sand. 1–0.5	Medium Sand. 0.5–0.25	Fine Sand. 0.25–0.1	Very Fine Sand. 0.1–0.05	Silt. 0.05–0.005	Clay. 0.005–0.000
	•	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Gravelly Loam, 0–7 in., ...	94	27.3	72.7	5.5	6.3	3.0	5.2	8.9	52.9	18.1
Gravelly Loam, 12–20 in., ...	93	56.3	43.7	13.1	12.1	5.4	8.9	4.3	36.6	19.5

Only one sample of this soil was analyzed. As in the Chenango loam the potash is practically the same in the soil and subsoil. The ratio of acid soluble to total potash is 1 : 3.93. The insoluble matter constitutes nearly 80%, which is less than is found in the loams generally, excepting the Dutchess series. The ratio of lime to magnesia in the soil is 1 : 3.7 and in the subsoil it is 1 : 8. There is more alumina than iron and more of each in the subsoil than in the soil. The phosphoric acid is about 0.15% in both soil and subsoil. The percentage of nitrogen in the soil is 0.183, which is above the average. This is equivalent to nearly 4,400 pounds per 8-inch acre. The ratio of nitrogen to total carbon is 1 : 10.5.

FOX GRAVELLY LOAM.

Location,	1⅓ Mi. S. of Newton. 21-35-4-9-9-6	
Depth of Sampling,	0″–7″	12″–20″
Soil Number,	94	93
Insoluble Matter,	79.57	79.84
Soluble Silica, SiO_2,	.06	.06
Potash, K_2O,	.31	.40
Soda, Na_2O,	.08	.08
Lime, CaO,	.23	.14
Magnesia, MgO,	.85	1.11
Manganese Oxide, Mn_3O_4,	.06	.04
Ferric Oxide, Fe_2O_3,	3.75	5.09
Alumina, Al_2O_3,	5.92	7.19
Phosphorus Pentoxide, P_2O_5,	.149	.147
Sulphur Trioxide, SO_3,	.08	.07
Carbon Dioxide, CO_2,	.07	.025
Volatile Matter,	8.63	5.85
Nitrogen,	.183	.067
Total Carbon,	1.92	.474
Total Potash,	1.38	1.41
Total Soda,	....	....
Total Phosphorus Pentoxide,	.159	.150
Hygroscopic Moisture,	....	....

CHENANGO SERIES.

The soils of the Chenango series occur in the upper Delaware Valley. They are soils having a brown to dark-brown surface and vary in texture with the different types. This series represents deposits made by the river when it was flowing at a higher level than at the present time. The types mapped are a silt loam, loam, fine sandy loam, sandy loam, fine sand, and sand.

Following are the results of mechanical analyses of representive samples of the different types:

RESULTS OF MECHANICAL ANALYSES OF REPRESENTATIVE SAMPLES OF THE CHENANGO SERIES.

SOIL TYPE.	Soil Number.	Coarse Gravel. Over 2 mm.	Fine Earth. Und. 2 mm.	Fine Gravel. 2–1	Coarse Sand. 1–0.5	Medium Sand. 0.5–0.25	Fine Sand. 0.25–0.1	Very Fine Sand. 0.1–0.05	Silt. 0.05–0.005	Clay. 0.005–0.000
		Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Fine Sandy Loam, 0–10 in., ...	189	.14	99.8	.23	.06	2.6	32.11	16.67	39.30	8.92
Fine Sandy Loam, 12–20 in., ...	190	0.00	100.	.02	.05	.74	26.71	19.47	43.54	9.57
Loam, 0–10 in., ..	181	.03	99.7	.03	.22	.81	16.3	23.88	47.02	11.74
Loam, 12–20 in.,.	182	0.00	100.	.04	.07	.37	10.51	26.80	48.41	13.80
Silt Loam, 0–10 in., ...	187	0.00	100.	.12	.40	1.94	9.84	11.25	57.37	19.09
Silt Loam, 12–20 in., ...	188	0.00	100.	.025	.36	1.66	11.67	13.84	50.65	21.82
Sandy Loam, 0–8 in., ...	191	3.0	97.	7.93	13.6	26.18	24.78	5.08	15.33	7.11
Sandy Loam, 12–20 in., ...	192	4.7	95.	8.96	12.5	25.73	28.37	5.69	12.94	5.74
Fine Sand, 0–10 in., ...	197	.3	99.7	.135	.460	8.38	49.35	18.88	18.13	4.678
Fine Sand, 12–20 in., ...	198	0.00	100.	.03	.40	7.06	31.36	16.7	33.78	10.78
Sand, 0–8 in., ...	193	0.00	100.	.45	11.5	40.88	27.59	7.95	7.53	4.15
Sand, 12–20 in., .	194	0.00	100.	.73	13.96	40.78	26.25	4.42	8.97	5.00

The Chenango series of soils are high in insoluble matter, the average for the six types being close to 90%. On the other hand nearly all the members of the series contain a lower percentage of plant food constituents than most of the series encountered in the area. The acid-soluble potash varies from 0.14 to 0.34%, while the highest total potash is 1.59 and the lowest 0.65%. In most cases not more than a trace of lime was found, the highest being 0.1% in the loam. The magnesia varies from 0.3% to 0.56%. Throughout the series the iron and alumina are unusually low, as is also the volatile matter. The acid-soluble phosphoric acid varies from 0.06 to 0.18 with an average in both soils and subsoils of 0.1%. In nearly all cases the total phosphoric acid is slightly higher than the acid-soluble. The nitrogen and total carbon are both low, indicating a deficiency of humus.

CHENANGO FINE SANDY LOAM.

Location,	1 Mi. N. Montague. 21-5-7-5-1-7		1½ Mi. N. W. Layton. 21-14-5-8-7-3		Average.	
Depth of Sample,	0"-10"	12"-20"	0"-8"	12"-20"	Soil.	Sub-soil.
Sample Number,	189	190	195	196		
Insoluble Matter,	90.40	91.91	88.67	91.86	89.53	91.88
Soluble Silica, SiO_2,	.07	.07	.07	.04	.07	.055
Potash, K_2O,	.11	.21	.14	.16	.125	.185
Soda, Na_2O,	.14	.06	.06	.05	.1	.055
Lime, CaO,	....	.06	TRACE	TRACE	TRACE	.03
Magnesia, MgO,	.50	.45	.40	.47	.45	.46
Manganese Oxide, Mn_3O_4,	.04	.045	.05	.01	.045	.027
Ferric Oxide, Fe_2O_3,	2.03	1.91	1.89	2.18	1.96	2.04
Alumina, Al_2O_3,	2.94	2.96	3.24	2.95	3.09	2.95
Phosphorus Pentoxide, P_2O_5,	.097	.08	.181	.069	.139	.074
Carbon Dioxide, CO_2,	.027	.01	.02	.005	.023	.007
Volatile Matter,	3.78	2.18	5.30	2.27	4.54	2.22
Nitrogen,	.07	.029	.118	.022	.094	.025
Total Carbon,	.89	.435	1.46	.21	1.175	.322
Total Potash,	1.16	1.21	.76	.94	.96	1.075
Total Soda,	.97	.37	.34	.44	.655	.405
Total Phosphorus Pentoxide,	.118	.082	.213	.071	.165	.076

CHENANGO LOAM.

Location,	2 Mi. N. W. Hainesville. 21-14-3-4-7-6		2 Mi. S. W. Bevans. 21-24-4-1-1-6		Average.	
Depth of Sample,	0–10″	12–20″	0–7″	12–20″		
Sample Number,	181	182	130	129	Soil	Sub-soil
Insoluble Matter,	89.39	89.54	90.09	89.81	89.74	89.625
Soluble Silica, SiO_2,	.07	.06	.05	.05	.06	.055
Potash, K_2O,	.26	.17	.27	.27	.265	.220
Soda, Na_2O,	.08	.08	.14	.09	.110	.085
Lime, CaO,	.10	.10	.10	.07	.10	.085
Magnesia, MgO,	.50	.56	.43	.57	.465	.565
Manganese Oxide, Mn_3O_4,	.06	.10	.08	.10	.07	.10
Ferric Oxide, Fe_2O_3,	2.41	2.88	2.44	3.21	2.425	2.545
Alumina, Al_2O_3,	3.24	2.98	2.88	3.23	3.060	3.105
Phosphorus Pentoxide, P_2O_5,	.095	.087	.134	.147	.114	.117
Carbon Dioxide, CO_2,	.02	.025	.065	.02	.042	.022
Volatile Matter,	4.01	3.53	3.46	2.60	3.735	3.065
Nitrogen,	.094	.062	.076	.047	.085	.054
Total Carbon,	.996	.593	.713	.265	.854	.429
Total Potash,	1.47	1.59	1.13	1.48	1.300	1.535
Total Soda,	.65	.55	....	....	.65	.55
Total Phosphorus Pentoxide,	.112	.109	.15	.153	.131	.131

	Chenango Silt Loam.		Chenango Sandy Loam.		Chenango Fine Sand.		Chenango Sand.	
Location,	3 Mi. S. W. Tri-States Rock. 22-1-4-8-7		1 Mi. S. W. Montague. 21-14-3-3-4-7		2 Mi. N. W. Layton. 21-14-5-7-5-2		2 Mi. N. W. Hainesville. 21-14-2-9-3-3	
Depth of Sample,	0″–10″	12″–20″	0″–8″	12″–20″	0″–10″	12″–20″	0″–8″	12″–20″
Sample Number,	187	188	191	192	197	198	193	194
Insoluble Matter,	87.64	88.89	91.25	94.18	92.92	91.06	92.99	92.71
Soluble Silica, SiO_2,	.07	.05	.08	.05	.07	.03	.08	.08
Potash, K_2O,	.16	.34	.14	.15	.21	.22	.137	.14
Soda, Na_2O,	.08	,07	.045	.065	.11	.04	.04	.04
Lime, CaO,	.06	.01	.04	.02	.02	TRACE	TRACE	TRACE
Magnesia, MgO,	.56	.51	.30	.32	.33	.50	.33	.34
Manganese Oxide, Mn_3O_4,	.15	.11	.045	.015	.065	.05	.01	.015
Ferric Oxide, Fe_2O_3,	2.82	3.20	1.39	1.34	1.89	2.41	1.94	2.10
Alumina, Al_2O_3,	3.99	3.61	2.63	2.43	2.18	2.95	2.35	2.78
Phosphorus Pentoxide, P_2O_5,	.136	.132	.156	.082	.063	.118	.104	.09
Carbon Dioxide, CO_2,	.025	.015	.020	.005	.01	.01	.02	.005
Volatile Matter,	4.25	2.89	3.78	1.69	2.13	2.52	2.01	1.70
Nitrogen,	.079	.032	.087	.023	.038	.029	.032	.014
Total Carbon,	.84	.339	1.06	.132	.387	.222	.398	.118
Total Potash,	1.44	1.55	.65	.78	1.11	1.24	.71	.896
Total Soda,	.55	.52	.28	.32	.48	.47	.25	.27
Total Phosphorus Pentoxide,	.158	.132	.169	.09	.076	.12	.117	.094

GENESEE SERIES.

The better-drained bottom land soils of the area are represented by the Genesee loam. Where there is little danger from inundation it is a valuable type for the production of cultivated crops, especially corn. Following are the mechanical analyses of this type:

RESULTS OF MECHANICAL ANALYSES OF A REPRESENTATIVE SAMPLE OF GENESEE LOAM.

SOIL TYPE.	Soil Number.	Coarse Gravel. Over 2 mm.	Fine Earth. Und. 2 mm.	Fine Gravel. 2–1	Coarse Sand. 1–0.5	Medium Sand. 0.5–0.25	Fine Sand. 0.25–0.1	Very Fine Sand. 0.1–0.05	Silt. 0.05–0.005	Clay. 0.005–0.000
		Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Loam, 0–8 in., ..	57	6.1	94.9	1.17	1.74	3.29	14.89	24.17	34.78	21.09
Loam, 12–20 in.,	58	4.4	95.6	.2	1.47	1.98	19.30	27.56	28.21	22.72

Genesee Loam.

Two samples of soil and two of subsoil were analyzed from the Genesee loam. The sample from near Sparta is low in acid-soluble potash, and unusually high in total potash, the ratio being 1 : 17.4. The ratio of acid-soluble to total potash in the soil and subsoil of the Sussex sample is 1 : 5.48 and 1 : 4.9 respectively. It is of interest to note that the amount of potash in an acre of the Sparta sample to the depth of 20 inches is 177,600 pounds (88.8 tons), but that a comparatively small proportion of this, 10,200 pounds (5.1) tons, is soluble in strong hydrochloric acid.

The ratio of lime to magnesia in the soil and subsoil of the Sparta sample is 1 : .82 and 1 : 1 respectively, while in the Sussex sample it is 1 : 4.7 and 1 : 5.3. From the amount of carbon dioxide present in the Sparta sample it is apparent that this soil contains considerable carbonate of lime or magnesia or both. The Sussex samples, on the other hand, are low in lime and contain scarcely more than a trace of carbon dioxide. The average amount of phosphoric acid in the two samples is about the same as is found in the loams generally and there is slightly more in the subsoil than in the soil.

GENESEE LOAM.

Location,	1½ Mi. N. E. of Sparta. 22–32–5–5–1–9		S. of Road Across Clove River in Sussex. 22–12–8–9–1–6		Average.	
Depth of Sampling,	0″–8″	12″–20″	0″–8″	12″–20″		
Soil Number,	163	164	57	58	Soil.	Sub-soil.
Insoluble Matter,	79.74	84.50	81.46	83.66	80.60	84.08
Soluble Silica, SiO_2,	.06	.04	.10	.07	.08	.05
Potash, K_2O,	.18	.16	.23	.36	.20	.26
Soda, Na_2O,	.09	.12	.04	.04	.06	.08
Lime, CaO,	1.42	.74	.16	.15	.79	.44
Magnesia, MgO,	1.17	.75	.75	.80	.96	.77
Manganese Oxide, Mn_3O_4,	.07	.07	.04	.04	.05	.05
Ferric Oxide, Fe_2O_3,	3.53	4.64	3.23	3.45	3.38	4.04
Alumina, Al_2O_3,	4.53	3.79	4.68	5.35	4.60	4.57
Phosphorus Pentoxide, P_2O_5,	.163	.086	.13	.074	.146	.08
Sulphur Trioxide, SO_3,	....	....	.07	.06	.07	.06
Carbon Dioxide, CO_2,	.72	.07	.03	.015	.37	.04
Volatile Matter,	8.94	5.25	9.22	5.76	9.08	5.50
Nitrogen,	.219	.097	.20	.065	.209	.081
Total Carbon,	2.58	.964	1.85	.45	2.21	.707
Total Potash,	2.98	2.95	1.26	1.76	2.12	2.35
Total Soda,	1.83	1.97	....	....	1.83	1.97
Total Phosphorus Pentoxide,	.172	.11	.163	.078	.167	.094
Hygroscopic Moisture,	2.00	1.70	....	....	2.00	1.70

PAPAKATING SILT LOAM.

The Papakating silt loam represents the more poorly drained bottom land soils of the area. They are characterized by the dark drab surface soil and the grayish subsoil. In no cases are cultivated crops successful on this type, though it offers bright prospects, where the drainage can be improved, as a pasture or grass land. Following are the mechanical analyses which show the relatively high amount of silt and clay, indicating it to be the heaviest soil in the area:

RESULTS OF MECHANICAL ANALYSES OF REPRESENTATIVE SAMPLES OF PAPAKATING SILT LOAM.

SOIL TYPE.	Soil Number.	Coarse Gravel. Over 2 mm.	Fine Earth. Und. 2 mm.	Fine Gravel. 2–1	Coarse Sand. 1–0.5	Medium Sand. 0.5–0.25	Fine Sand. 0.25–0.1	Very Fine Sand. 0.1–0.05	Silt. 0.05–0.005	Clay. 0.005–0.000
		Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Silt Loam, 0–7 in., ...	173	1.5	98.5	.8	2.1	1.7	6.2	7.4	67.5	13.9
Silt Loam, 12–20 in., ...	174	4.4	95.6	2.0	3.3	2.7	11.5	17.6	48.0	14.5

Two samples each of soil and subsoil of this type were analyzed. The potash does not differ greatly from the amount found in the Dutchess series. Like nearly all types so far examined, there is more of both acid-soluble and total potash in the subsoil than in the soil. The surface soil is characterized by a rather high percentage of lime, magnesia, nitrogen, and total carbon. The nitrogen in the surface soil is 0.35%, which is equivalent to 8,400 pounds per 8-inch acre. If only 1/100 part of this could be made available each year it would supply enough nitrogen for many crops. Lime and magnesia are present in the soil in the ratio of 1 : 1.87 and in the subsoil 1 : 2.55.

PAPAKATING SILT LOAM.

Location,	1 Mi. S. E. of Monroe Corners. 22–22–8–7–6–16		1½ Mi. S. W. of Sussex. 22–22–2–1–5–7–N. W.		Average.	
Depth of Sample,	0″–7″	12″–20″	0″–6″	12″–20″		
Sample Number,	173	174	175	176	Soil.	Subsoil.
Insoluble Matter,	....	....	....	....	....	....
Soluble Silica, SiO_2,	.06	.04	.05	.03	.05	.03
Potash, K_2O,	.25	.36	.35	.51	.30	.43
Soda, Na_2O,	.06	.20	.23	.08	.14	.14
Lime, CaO,	.62	.45	.31	.22	.46	.33
Magnesia, MgO,	.68	.89	1.04	.79	.86	.84
Manganese Oxide, Mn_3O_4,	....	.03	.03	.01	....	.02
Ferric Oxide, Fe_2O_3,	1.60	3.09	3.73	3.27	2.66	3.18
Alumina, Al_2O_3,	4.93	4.37	7.29	4.21	6.11	4.29
Phosphorus Pentoxide, P_2O_5,	.132	.114	.165	.047	.148	.08
Carbon Dioxide, CO_2,	.02	.015	.025	.025	.02	.02
Volatile Matter,	....	....	....	....	....	....
Nitrogen,	.345	.053	.353	.043	.349	.048
Total Carbon,	3.86	.40	.322	.254	3.54	.33
Total Potash,	1.89	2.39	1.41	1.25	1.65	1.82
Total Soda,	1.34	1.40	1.13	1.12	1.23	1.26
Total Phosphorus Pentoxide,	.152	.125	.185	.05	.168	.087
Hygroscopic Moisture,	3.29	1.11	3.80	.83	3.54	.97

MUCK.

Muck is found in varying sized sections over the entire area. It offers excellent possibilities for the development of intensive agriculture wherever it can be drained.

Under the heading of muck comes three samples of muck and a shell marl subsoil overlaid with humus. These samples are characterized by a low percentage of insoluble matter, potash, magnesia, iron and alumina. They are high in lime, volatile matter, nitrogen and total carbon. With two exceptions, the nitrogen is over 2%. The phosphoric acid corresponds closely with the amount usually found in the loam soils of this section.

With drainage, and thorough and deep cultivation to aid in oxidizing the poisonous compounds, many of these muck soils will prove well adapted to the growing of vegetables. Such soils, when well prepared, will require little or no commercial nitrogenous fertilizers. Such as are used should be in a readily available form, as there is an abundance of organic nitrogen present.

MUCK.

Location,	⅔ Mi. S. W. of Sparta. 22–32–7–3–4–4	3 Mi. S. Woodbourne. 22–22–4–3–8–1	200 yds. E. of Owens. 22–13–4–3–6–3	1 Mi. W. of Vernon. 22–13–9–7–4–8	1 Mi. N. E. of Lafayette. 22–22–4–5–8–1	
					Muck.	Marl.
Depth of Sampling,	0″–36″	0″–36″	0″–36″	0″–36″	0″–10″	10″–36″
Soil Number,	145	47	48	162	97	98
Insoluble Matter,	36.18	6.62	3.23	2.57	8.01	36.27
Soluble Silica, SiO_2,	.06	.04	.05	.09	.07	.13
Potash, K_2O,	.16	.08	.04	.07	.06	.20
Soda, Na_2O,	.07	.04	.04	.08	.04	.06
Lime, CaO,	2.31	3.08	2.95	4.65	5.32	28.51
Magnesia, MgO,	.27	.34	.35	.33	.46	1.10
Manganese Oxide, Mn_3O_4,	TRACE	.01	.01	TRACE	.....	.02
Ferric Oxide, Fe_2O_3,	2.46	.78	.72	1.03	1.78	2.03
Alumina, Al_2O_3,	1.78	.46	.13	.03	.70	1.73
Phosphorus Pentoxide, P_2O_5,	.158	.117	.113	.123	.140	.054
Sulphur Trioxide, SO_3,	.....	.48	.50	.....	.32	.47
Carbon Dioxide, CO_2,	.11	.18	.14	.60	1.25	21.33
Volatile Matter,	54.35	86.15	91.42	88.95	82.31	29.28
Nitrogen,	.1893	2.583	2.70	2.66	2.12	.197
Total Carbon,	6.16	38.80	42.23	39.07	28.91	8.38
Total Potash,	1.31	.10	.18	.08	.19	.76
Total Soda,	.....	.....	.....	.12	.....	.....
Total Phosphorus Pentoxide,	.186	.135	.157	.15	.156	.061
Hygroscopic Moisture,	12.28	.....	.....	31.94	.....	.....

SUMMARY.

The soils of the Sussex area are generally well supplied with potash. There is almost invariably more in the subsoil than in the soil. In a majority of the samples the acid-soluble potash varies from about 0.2 to 0.3%, while the total is frequently as high as 2.00 to 3.00%.

Phosphoric acid is found in fair amounts; in some samples running close to 0.2%. There is slightly less in the subsoil than in the soil, while the total is only a little in excess of the acid-soluble.

Many of the soils are quite deficient in lime, while some contain only a trace of this material. Magnesia is almost invariably present in excess of the lime.

Many of the soils are fairly well supplied with nitrogen, though some, on the other hand, are quite deficient in this material. Generally there is about three to four times as much nitrogen in the soil as in the subsoil.

Applications of lime, together with more thorough cultivation, and a more extended use of green manure crops, will do much towards making these soils more productive than they are at present.

Dutchess Series.—These soils are low in lime and high in magnesia; they are generally fairly well supplied with nitrogen, phosphoric acid and potash.

Gloucester Series.—The Gloucester soils are generally well supplied with potash and lime, while magnesia is not greatly in excess, the lime magnesia ratio being about 1 : 3. They contain a fair amount of phosphoric acid and nitrogen.

Dover Series.—These soils are of limestone origin, though they now contain only moderate amounts of lime, less than 0.2% in several samples. The loam contains about the average amount of phosphoric acid and nitrogen and is high in total potash. The stony loam is low in phosphoric acid and nitrogen.

Hoosic Series.—The Hoosic soils are low in lime, less than 0.2% in most cases. They are well supplied with phosphoric acid and nitrogen.

Chenango Series.—These soils are very deficient in lime and are low in nitrogen and phosphoric acid.

Papakating Silt Loam.—This soil is well supplied with lime and has a high nitrogen content.

Lackawanna Loam.—Very deficient in lime and low in nitrogen and phosphoric acid.

Wallpack Silt Loam.—Low in lime and potash.

Wallpack Shale Loam.—High in nitrogen, fair amount of lime and potash.

Genesee Loam.—High in lime and nitrogen.

Analysis of Soils—Methods Used.

BY R. B. GAGE.

Contents.

Most of the methods used in making the determinations described herein are those recommended by the Association of Official Agricultural Chemists, or are modifications of those methods. Whenever it was found that the official methods could be shortened or better results secured by modifying them, this

was done. In some cases methods not recommended by this association were used, but only after they had been checked with standard gravimetric methods and found to give accurate results.

Since a slight variation in manipulating most of these methods is accompanied by a corresponding change in the results secured, the manner in which they were carried out is described in more detail than would otherwise be done.

SAMPLE.

The samples analyzed consisted of that portion of the air-dried soil which passed a 1 m. m. sieve. These samples were kept in glass-covered jars and used without further drying.

The quantity of a sample used for some of the determinations was larger than that generally recommended. This often saved making a second acid digestion when some duplicate determination was desired. By working on from 2 to 10-gram samples the errors were reduced accordingly.

GENERAL COMMENTS ON THE METHODS USED.

The average soil is not composed of ingredients that are readily soluble or totally insoluble in the acid used for making the acid extraction, but contain certain minerals which are attacked very slowly. Even when the acid is of a definite strength and the digestion made in a given manner for a definite length of time, the quantity of soil dissolved varies with the style of flask used, and the manner in which these flasks sit on the water bath. A standard Jena Erlenmeyer 500 cm^3 flask 7 inches high and 4 inches in diameter was used for making all acid extractions. These flasks were placed on a water bath containing openings 3½ inches in diameter. The flasks were closed by a rubber stopper containing a glass condensing tube 20 inches long with an inside diameter of about ¼ inch. The water bath was boiling when the flasks were placed upon it.

The iron contents of the soil are reported as ferric oxide, yet some if not all of this metal exists in the ferrous condition in the

soil. Since the ferrous oxide was not determined, no correction in the insoluble residue was made for this gain in weight during heating of the insoluble residue.

To secure a complete precipitation of phosphorus as ammonium phospho-molybdate that will be comparatively free from impurities, it is quite necessary that the solution be rich in ammonium nitrate and iron, and of about a certain acidity. This excess of iron aids very much in securing the desired acidity and at the same time reduces the chances of any molybdic acid precipitating with the phosphorus. Moreover, the ammonium phospho-molybdate precipitate appears to come down quicker and to be of a more uniform composition where the solution is in the condition given above.

When the phosphorus is precipitated in the manner given herein, the results secured by titrating the yellow precipitate with a standard alkali solution are just as accurate as those secured by gravimetric methods. This is not true, however, with materials containing over 1 per cent. of phosphoric pentoxide.

The method given to determine the total alkalies was checked on several soils with the J. Lawrence Smith method, and always gave the same or slightly higher results. It does not require the close attention or as much work as the latter method and the losses from volatilization are much reduced.

ACID EXTRACTION.

Twenty grams of the air-dried soil are digested with 200 cm^3 of dilute hydrochloric acid (see reagents) continuously on the water bath for 10 hours. The flasks are shaken by hand at the end of each hour so the contents will be thoroughly mixed. After digestion the solution is filtered at once through a double filter paper[1] directly into a 500 cm^3 graduated flask.

The filtrate should be perfectly clear and show no cloudiness. Otherwise some silt or clay has passed through the filter. When

[1] The filters used were S. and S. Blue Label, 9 and 11 cm, respectively. The 9 cm paper is placed on the inside. This combination filters much quicker than when both papers are of the same size.

this happens, the solution should be refiltered if a soluble silica determination is made.

The insoluble residue is washed a few times by decantation and then on the paper with hot water until free from chlorides. It is ignited in a 30 cm^3 platinum crucible, first over the Bunsen burner and then blasted. The residue should always be broken up during ignition. If not some of the filter paper at the bottom of the crucible may escape incineration.

If the analyst has the necessary apparatus and laboratory equipment, much time is saved by starting all the following determinations at once: soluble alkalies, sulphuric acid, total iron, soluble phosphoric acid, and a general analysis for alumina, ferric oxide, lime, magnesia and manganese oxide. Since each 25 cm^3 of this solution corresponds to 1 gram of soil there is sufficient solution to make most determinations in duplicate if desired.

IRON, ALUMINA, LIME, MAGNESIA, ETC.

Transfer 50 cm^3 of the stock solution to a 250 cm^3 beaker, add 25 cm^3 of strong hydrochloric acid, dilute to about 100 cm^3, and then neutralize the excess of acid with ammonia before heating. The covered solution is heated nearly to boiling, from one-quarter to one-half gram of ammonium persulphate added and then ammonia in slight excess. The solution is kept near the boiling point for from 15 to 20 minutes after making it ammoniacal so the manganese and alumina will all be precipitated.

After the precipitate has settled, the solution is filtered at once. The precipitate is washed but a few times on the paper when it is returned to the beaker and dissolved in hot dilute nitric acid and reprecipitated in the same manner as before, except a smaller amount of ammonium persulphate is used and no hydrochloric acid is added. The solution is again filtered through the same paper as before and the precipitate washed free of chlorides with hot water. The small amount of the precipitate, which adheres to the sides of the beaker, is removed with a

small piece of filter paper, and added to the major portion. The wet precipitate and paper are transferred at once to a 20 cm³ platinum crucible, slowly ignited over a Bunsen burner and then blasted to a constant weight. Since this precipitate contains more or less ammonium nitrate, there is little danger of any iron oxide being reduced during ignition. These oxides are saved and their manganese contents determined in the manner given below. The alumina is determined by deducting the combined weights of the ferric oxide, phosphorus pentoxide, mangano-manganic oxide from the total weight of the oxides.[1]

The combined filtrates from these oxides should be concentrated to about 100 cm³. A slight precipitate of iron and alumina may come down upon the addition of a few drops of ammonia at this point and should be filtered off and added to the other oxides. The hydrate of alumina is quite soluble in hot water when neutral. If the solution contains much organic matter, which is not destroyed by the persulphate, some of these metallic oxides are quite sure to be held in solution.

Unless the above solution contains a large excess of ammonium chloride, more or less magnesia will come down with the iron-alumina precipitate, and is not always removed by a second precipitation. The ammonium persulphate precipitates the manganese with the iron and alumina. If the soil is rich in lime, hydrogen peroxide free from sulphuric acid had better be used instead of the persulphate.

The second precipitation is necessary to secure the small amount of lime and magnesia carried down with the iron and alumina. It also shortens the final washing of the precipitate and reduces the loss by volatilization.

LIME.

The concentrated filtrates are heated to boiling and the lime is precipitated by the addition of about 10 cm³ of a saturated

[1] If the soil contains any titanium, more or less of it will go into solution, and will be precipitated with the iron and alumina, and a correction will have to be made for it. It had best be determined as given in Bulletin 305 of the U. S. Geological Survey.

solution of ammonium oxalate. The lime precipitate forms slowly in a coarse crystalline condition, for the solution is about neutral. After the lime has nearly all precipitated the solution is made distinctly ammoniacal and kept near the boiling point for about 30 minutes before filtering. The precipitate is collected on a thick, close-grained paper. When the precipitate is quite large, it is washed a few times by decantation and then dissolved in dilute nitric acid, a few drops of the ammonium oxalate solution added, and then re-precipitated by adding ammonia slowly to the hot solution. The bulk of the solution is kept as small as possible, and hot for about 20 to 30 minutes before filtering. The precipitate is washed with hot water, ignited and blasted to a constant weight.

This precipitate may contain a slight amount of manganese or alumina for which a correction in the lime content must be made. It should be dissolved in a little dilute nitric acid, washed into a small beaker, the manganese reduced with a few drops of sulphurous acid and the alumina precipitated by ammonia in the usual manner. The manganese is determined in the filtrate from the alumina in the same manner as given below. Very seldom more than traces of manganese will be found.

MAGNESIA.

The magnesium is precipitated as a phosphate in the usual manner. The solution is allowed to stand from 24 to 48 hours before filtering. If the soil contains over 5 per cent. of soluble magnesia, the clear solution should be decanted off, the precipitate dissolved in a little dilute nitric acid, a few drops of phosphate solution added, and the magnesium re-precipitated by the addition of ammonia drop by drop until the solution is strongly ammoniacal. After standing several hours this solution is filtered through the same paper used for the first solution, and washed free of chlorides with a 10 per cent. solution of ammonia, ignited very slowly over a Bunsen burner, then blasted to a constant weight.

The precipitate will often harden and burn white very slowly. When this happens moisten it with a few drops of strong nitric

acid, evaporate off the excess of the same on the hot plate, heat very cautiously until the crucible becomes dull red, then blast and weigh. This precipitate should be dissolved in hot dilute nitric acid and tested for manganese. If the manganese is separated by hydrogen disulphide or bromine water, some is sure to be found with this precipitate.

MANGANESE.

The crucible containing the iron and alumina residue is filled about one-third full of fused $KHSO_4$ and heated gently over a low flame of the Bunsen burner until the mass has fused, when the heat is increased enough to just redden the bottom of the crucible. The crucible is kept covered and the heating continued until the residue has gone into solution. After the melt has cooled it is transferred to a small beaker, containing about 75 cm^3 of water and 5 cm^3 of sulphuric acid, and heated slowly until the fusion has dissolved. Often small flakes of silica will separate out. They should be filtered off and the silica determined in the usual manner. The amount thus found is deducted from the total weight of the oxides to get the true weight of the iron, alumina, mangano-manganic oxide and phosphoric pentoxide.

To the hot filtrate, or the unfiltered solution if the silica is not filtered off, from 2 to 10 cm^3 of silver nitrate solution are added according to the manganese content of the soil and then about 1 gram of ammonium persulphate, and the solution heated for about 15 minutes after the pink color of the permanganate has begun to show. This heating after the color of the manganese begins to show is quite necessary, for often the color developed is an old rose instead of a pink. This is caused in part by a brownish color produced by the action of the persulphate on the silver nitrate when too much nitrate has been added, and will often disappear on heating. Some of the color, however, is due to the yellow color given the solution by the iron present, and a correction must be made for it in preparing the standard. After the color has attained its maximum, the beaker is set in a

pan of cold water, and when cool compared with a standard solution whose value in manganese is known.

This solution can best be prepared by diluting the required amount of the standard permanganate solution so each cm^3 will equal .00002 grams of MnO*. If the standard permanganate solution has a value of .0025 grams of iron per cm^3, 15.8 cm^3 of this solution diluted to 500 cm^3 will give a solution of the desired strength. Of this solution 50 cm^3 is transferred to a small beaker, 5 cm^3 of dilute sulphuric acid (1-1) added and a few drops of sulphurous acid to destroy the permanganate color. This color is again restored in the same manner as given above. This standard will show the true permanganate color, which will have a different tint from that of the sample on account of the iron in the latter. Just before removing the two solutions from the hot plate, and while they are at about the same temperature, add a solution of ferric nitrate, drop by drop, to the standard until it has the same color as the sample. This off color is more pronounced in the hot solution than when cooled, consequently it is much easier matched at this time. Unless this correction is made, it is impossible to compare the two solutions with any degree of satisfaction. It is taken for granted that the ferric nitrate contains no manganese.

When a solution is too rich in manganese, manganese dioxide will be precipitated, which gives the solution a brownish color that does not disappear on heating. When this happens, increase the volume of the solution by adding hot water, dissolve the precipitate in a few drops of sulphurous acid, and reheat after adding a little more persulphate. To prevent this formation of manganese dioxide, the volume of the solution may have to be increased to 500 cm^3 or more.

When cool the standard is transferred to a 100 cm^3 flask, diluted to the mark and well mixed. Each cm^3 now contains .00001 grams of MnO. The sample likewise is diluted to 250 cm^3 or 500 cm^3, according to the amount of manganese present. for the sample should always be lighter in color than the standard. Fifty cm^3 of the sample are transferred to a Nessler

* A solution of this strength has about the proper depth of color.

cylinder, and known amounts of the standard added to another cylinder until the color is nearly the same, when the standard is diluted so each cylinder will contain about the same amount of liquid before the final reading is taken.

It is possible to determine one one-hundredth of one per cent. of MnO by this method, and for the small amount of MnO usually found in soils is much shorter and more accurate than any of the other methods. When the MnO content of the soil is above 1½ per cent., any slight error in reading the color will make quite an error in the final results. Consequently, in soils of this type, the manganese had better be determined by some other method.

While making this determination it is necessary to keep the room free from HCl fumes, and the water used must also be free from chlorides, for it is almost impossible to filter off traces of silver chloride, which will mar the end reading more or less. For a further description of this method as applied to rocks, see Bulletin U. S. Geological Survey No. 305, page 99.

SOLUBLE PHOSPHORUS AND SILICA.

Evaporate 125 cm³ of the stock solution to complete dryness in a porcelain casserole on a water or steam bath. When nearly to dryness the residue is broken up several times so it will be completely dehydrated. If it is not thoroughly dry or is heated too high, an insoluble compound will be formed later, which may contain phosphorus. For this reason this evaporation cannot be made over an open flame or on a hot plate. When the residue has become thoroughly dry, cover the dish and add 20 cm³ of strong nitric acid, and replace on the bath. The dish should be watched for a few moments, for if much organic matter is present the reaction will be quite vigorous. In the latter case, remove it from the bath for a few moments. The heating is continued until all the red fumes have been driven off. The solution is then diluted with hot water and filtered at once. The paper is transferred to a platinum crucible and the silica determined in the usual manner, while the phosphorus is determined

in the filtrate in exactly the same manner as given under total phosphorus after the insoluble residue has been filtered off.

SOLUBLE ALKALIES.

Transfer 50 cm^3 of the stock solution to a 200 cm^3 platinum or silica dish, add about 1 cm^3 of strong sulphuric acid and evaporate to dryness. The excess of sulphuric acid is then slowly expelled and the residue heated very slowly to a dull red and kept at this temperature until the organic matter has been incinerated. More or less of the sulphates of iron and alumina will be reduced to the oxides, and will not go back into solution again. This reduces the bulk of the precipitates of these two metals very much, making the separation of the alkalies from them much easier.

The residue is taken up in about 100 to 125 cm^3 of water and digested until the soluble sulphates have gone into solution. The alumina and iron is precipitated by ammonia and filtered off. This precipitate should be thoroughly washed to remove as much of the alkalies held by it as possible. When a soil is high in soluble alkalies the iron-alumina precipitate should be washed back into the platinum dish, dissolved in a few drops of HCl, and re-precipitated to remove the alkalies held by it.

The filtrate is caught in a platinum dish and evaporated quickly to dryness and heated slowly to a dull red to drive off as much of the ammonium sulphate as possible. The residue is then digested with about 50 to 75 cm^3 of water, a few drops of ammonia and ammonium carbonate added, and the heat continued until about one-half the volume of the liquid has been evaporated off. The last trace of alumina will usually be thrown down during this evaporation, which will not be the case if the solution is filtered much sooner. The filtrate is collected in a weighed platinum dish and quickly evaporated to dryness, and the residue again heated to a dull red. It is always advisable to dissolve the residue in a little hot water and test again for alumina and lime in the same manner as given above before weighing. This last evaporation will also help to remove the last traces of ammonium

sulphate. When the alkalies are free from alumina and lime they are heated to a dull red, cooled in a dessicator and weighed as sodium and potassium sulphates.

To separate the sodium and potassium, dissolve the sulphates in a little hot water, transfer to a 100 cm^3 silica dish, dilute to about 50–85 cm^3 depending on the weight of the alkalies, add about 5 cm^3 of hydrochloric acid and enough platinum chloride to convert both the sodium and potassium into the corresponding platinates.[1] The solution is concentrated either on the hot plate or the water bath until the residue is pasty when hot, but mostly solidifies on cooling. A dark ring should be prevented from forming around the outer edge of the residue by keeping it moistened with the mother liquid. The residue should be a yellow color and not red. It is then moistened with 50 to 75 cm^3 of alcohol (see reagents), and allowed to stand for several hours before filtering. The solution is finally filtered through a 7 cm^3 paper and the insoluble portion washed free from platinum chloride with the same alcohol. The paper and precipitate are removed from the funnel and placed on a large, open filter paper so the alcohol will quickly evaporate off. The funnel is also washed free from alcohol. When the paper is dry it is returned to the funnel, the potassium chloro-platinate dissolved in hot water and collected in a weighed platinum dish. The solution is evaporated to dryness on the water bath, cooled and weighed. This separation must be done in a room free from ammonia fumes.

The sodium sulphate is not always changed into the corresponding platinum salt during evaporation. When it is small in quantity it will all be dissolved in the alcohol and pass into the filtrate.

Since it is not very soluble in alcohol, it will often remain on the paper with the potassium chloro-platinate. In order to guard against this error, the residue after being freed from the platinum solution should always be washed with the ammonium chloride

[1] The weight of sulphates by 17 gives the number of cubic centimeters of a 10 per cent. solution of platinum chloride required.

solution until any sodium sulphate contained therein has been dissolved. The residue is then freed of chlorides by washing with the alcohol solution.

It is always advisable to dissolve the potassium chloro-platinate after weighing in a little hot water acidified with a few drops of HCl and test for SO_3 with barium chloride. If a precipitate is secured, it should be filtered off, weighed, calculated to sodium sulphate and deducted from the total weight of the platinate. The barium sulphate precipitate does not appear to inclose much, if any, potassium. Higher results are most generally secured by weighing the alkalies as sulphates than when they are weighed as chlorides.

The weight of K_2PtCl_6 by 0.19411 will give the per cent. of K_2O it contains.

The weight of K_2PtCl_6 by 0.3589 will give the corresponding K_2SO_4 it represents.

The weight of Na_2SO_4 by 0.4368 equals Na_2O.

TOTAL IRON AND SULPHUR TRIOXIDE.

Fifty cubic centimeters of the stock solution are diluted to about 125 to 150 cm^3; 1 cm^3 of hydrogen peroxide is added to oxidize the iron, and the iron and alumina precipitated in the same manner as given under iron, alumina, etc. After the precipitate has settled it is filtered off at once, washed a few times with hot water, and then returned to the beaker. It is dissolved in about 25 cm^3 of hot dilute sulphuric acid, and when in solution filtered through the same filter into a 250-cm^3 Erlenmeyer flask. The solution is evaporated until fumes of sulphur trioxide come off freely. The heating should be continued until all HCl has been expelled and the organic matter destroyed. After cooling 75 cm^3 of water are added and the solution heated until the soluble sulphates have all dissolved. This may take a little time, for some of these sulphates dissolve quite slowly. When the solution has cleared, a definite amount of granulated zinc is added and the solution kept hot until it has all dissolved. The solution is then cooled by setting the flask in a pan of cold water

and titrated at once with permanganate. A blank should always be run on the chemicals, for the zinc usually contains some iron. The top of the Erlenmeyer flask is closed with a 1-hole rubber stopper containing a small glass tube about 3 inches long to reduce the chances of oxidation.

If a manganese determination is not desired, or a more accurate determination of the iron is desired than can be obtained by this method, the iron should be reduced by H_2S, and determined in the manner given in U. S. Geological Survey Bulletin 305, page 90.

To the original filtrate from the iron and alumina, which has been caught in a large platinum dish, enough sodium carbonate is added to unite with all the sulphur trioxide present. The solution is then evaporated to dryness and the ammonium salts expelled slowly over a direct flame. The residue is dissolved in about 50 cm^3 of hot water and filtered into a small beaker. After the solution has come to a boil a few drops of HCl are added and then 5 cm^3 of a 10 per cent. solution of barium chloride. The beaker is set on the edge of the hot plate and allowed to evaporate nearly to dryness, so the barium sulphate will settle in a filterable condition. About 50 cm^3 of water are again added, and when the precipitate has settled it is filtered off, washed well with hot water, ignited over the Bunsen burner and weighed.

If the ferric chloride is not removed it will hold some of the barium sulphate in solution. The ammonium salts also tend to prevent a complete precipitation of the barium sulphate. The peroxide often contains sulphuric acid, and a correction should be made for the sulphur trioxide contained in the amount used.

TOTAL P_2O_5 IN SOILS BY THE $MgNO_3$ METHOD.

Treat 5 grams of the soil in a 3-3.5 inch porcelain dish with 6-8 cm^3 of the magnesium solution (see reagents) and evaporate to dryness over a low flame. The dish should be about 4 to 5 inches above the top of the burner. After the excess of water has been driven off, the flame is slowly raised until the bottom of the dish is quite red. The flame should be broad and cover as

much of the bottom of the dish as possible, and the heating continued until all the nitrates have been decomposed. If the dish is covered with a watch glass a more uniform heat is secured, and the red fumes, being held in the dish, act as a guide in indicating when the decomposition of the nitrates has ceased. This decomposition must be complete, otherwise some P_2O_5 may remain in the residue. There is little danger of heating too high, as no P_2O_5 is lost at red heat.

After the dish has cooled, moisten the residue with a little water and then add 15 cm^3 of strong HCl, keeping the dish covered during the addition. Place the dish over a low flame and evaporate slowly to dryness. The cover should be moved a little to one side, and the flame kept low and about 5 inches below the bottom of the dish. The heating is continued with this size of flame until the residue has become quite white, but the flame should not be high enough to decompose any of the ferric chloride and redden the residue in the bottom of the dish. When this happens it is best to moisten the residue as before and re-evaporate. It may take some time to whiten the residue, but if it is not done an insoluble compound will be formed later, which will contain some P_2O_5. The flame should not be increased to hurry the action at this point.

After the residue has whitened as much as possible it is moistened with 15 cm^3 of strong HNO_3 and heated for a few minutes more than required to expel all the red fumes, cooled some, diluted with hot water and filtered. A thick filter paper is used. If the operation has been carried out as given above the filtrate is clear. Should it show a cloudiness, it indicates the dehydrate heating was not large enough, while, on the other hand, if the residue is found to be red in the bottom, the heat was too high or too large a flame was used.

After the addition of about 10 cm^3 of ferric nitrate solution and 25 cm^3 of C. P. ammonia, nitric acid is added, drop by drop, until the solution has a distinct light amber color. Comparison of the color, which is variable, should be made with the temperature of the solution at 50°-60° C. When the proper color is secured, 3 cm^3 more nitric acid is added to prevent the precipita-

tion of any Al_2O_3 on concentrating. The solution is then evaporated down to about 75 cm, and should it get very dark red in color a little more acid is added. The solution should not be permitted to get too hot on adding the NH_3 and HNO_3, or some Al_2O_3 will precipitate. This does not go back into solution as easily as the Fe_2O_3. If the solution is too acid, the P_2O_5 will not all be precipitated, while, on the other hand, if too neutral, some alumina will separate out during the concentration or after the molybdate has been added. This white alumina precipitate will not dissolve in strong HNO_3, but will in strong HCl. Should it come down in very small amounts after the molybdate has been added, the determination is very little affected, if the yellow phospho-molybdate precipitate is titrated with KOH, but the result is affected if it is weighed. However, if it is large enough in quantity to prevent the proper washing of the phospho-molybdate precipitate it will spoil the determination. This alumina precipitate can easily be distinguished from the yellow phospho-molybdate precipitate, since it remains suspended in the solution much longer than the latter, and from molybdic acid, which crystallizes out on the sides of the flask. A soil high in soluble alumina will have to be made more acid than one low in the same. When the total "insoluble residue" is not above 75 per cent. the solution should be quite acid, unless the soluble part is very high in iron and organic matter. If much of this precipitate comes down, and the duplicates do not agree, the determination should be repeated, for when done correctly the results will not vary over 0.005 per cent. P_2O_5 in a sample containing 0.5 per cent. P_2O_5 or less.

After the solution has been evaporated to about 75 cm^3, and is of the right color at 50°–60°C., 10–20 cm^3 of molybdate solution (see reagents) are added, unless the soil contains over 0.5 per cent. P_2O_5, when more should be added. The temperature of the solution should be about 75°-80°C. when the molybdate is added, and after thorough mixing it is set in a warm place for a couple of hours before filtering.

If it is desired to weigh the yellow precipitate, filter into a gooch crucible, wash well with a 10 per cent. solution of am-

monium nitrate and then with a 2 per cent. solution of HNO_3, and once or twice with cold water, to remove the free acid, dry in water bath, cool and weigh at once, for the precipitate gains weight very fast, and will even gain weight in a dessicator unless the $CaCl_2$ is very dry.

If it is desired to titrate with KOH, filter onto a thick filter paper and wash[1] well with the ammonium nitrate solution, which should be neutral. After the precipitate has been washed free from the molybdate solution it is washed a couple of times with cold distilled water, for the ammonium nitrate solution is usually acid. The paper and precipitate are transferred to the Erlenmeyer flask used, about 25 cm^3 of cold water added and enough standard KOH solution to make the solution distinctly alkaline after the paper has been reduced to pulp by shaking in the closed flask. After adding a few drops of phenol-phthalein, the solution is allowed to stand for about five minutes to see if the pink color is permanent, and then standard nitric acid is added until the pink color has just disappeared. The difference will give the per cent. P_2O_5 if the KOH solution is standardized as given elsewhere.

TOTAL POTASH AND SODA.

The material for this determination should be ground exceedingly fine in an agate mortar. Coarse material lengthens the time of evaporation and may escape complete decomposition. This finely-ground material loses moisture easily, and should be kept in an air-tight bottle.

Transfer 1 gram of the powdered sample to a 200 cm^3 platinum dish and ignite carefully over a Bunsen burner until all organic matter has been destroyed. This heating also helps the acid to decompose the insoluble minerals present.

The calcined residue is then moistened with water and about 50 cm^3 of hydrofluoric acid added. Enough sulphuric acid is also added to form sulphates of the metallic oxides. For an

[1]If cold water is used at this point some molybdic acid will be thrown down and may not all be washed out of the yellow precipitate.

ordinary soil, from 5 to 8 drops will be sufficient. The solution is evaporated very slowly to dryness, so the acid will have ample time to decompose all the minerals. If the platinum dish is covered with one a size larger, the hydrofluoric acid is expelled very slowly. The residue is moistened again with about 25 cm^3 of hydrofluoric acid and the evaporation this time continued until all sulphuric acid has been driven off.

The residue is then digested with hot water until all the soluble salts have been dissolved. This may require some time if much lime is present. Two evaporations are usually sufficient to decompose most soils, but in case undecomposed minerals are seen or thought to be present, filter off the insoluble portion, ignite in a platinum crucible and treat the residue again with hydrofluoric and sulphuric acid, as above specified. This residue is added to the major portion of the sample after being dissolved in a little hot water.

In either case the iron and alumina are precipitated by ammonia. This precipitate is well washed to free it from alkalies. If the soil is high in alkalies it is often advisable to dissolve this precipitate in a little hydrochloric acid and re-precipitate to free it from enclosed alkalies. If the volume of the original solution is 200 cm^3 or more, and the precipitate washed well, a second precipitation is seldom required.

The filtrate is collected in a large platinum dish and quickly evaporated to dryness over a Bunsen burner. The determination is completed in the manner given for soluble alkalies.

CARBON DIOXIDE.

A modified form of the Knorr apparatus is used in making this determination. The CO_2 absorption bulbs were designed by the writer to reduce the chances of CO_2 being absorbed from the air during titration to a minimum. Very little time or attention is required in making a carbon dioxide determination with this apparatus, yet the results are very accurate. With five sets of this apparatus from 30 to 40 determinations can easily be made per day.

For soils not containing over one-half of 1 per cent of CO_2 a 10-gram sample is used. For those containing between one-half and 4 per cent. CO_2 a 5-gram sample is sufficient, and for soils above 4 per cent. and under 20 per cent. CO_2 a 1-gram sample is used.

The soil sample is introduced into the flask A (Plate I), which should always be dry. Air free from CO_2 is now passed through the apparatus until the flask A and absorption bulb S are free from CO_2. From 10 to 50 cm^3 of barium hydrate solution (see reagents), the amount depending on the CO_2 contents of the soil, are introduced into the bulb S and enough water added to bring the total volume of the solution up to about 60 cm^3. About 10 cm^3 of dilute hydrochloric acid (1 to 1) are introduced into the bulb B, which is quickly closed with stopper C containing soda lime. The tube H is connected with an air supply under slight pressure, and also free from CO_2. Bulbs E and F contain dilute solutions of potassium hydrate and silver nitrate, respectively.

The cock K is opened so the acid in bulb B will flow very slowly into flask A in order not to cause any sudden evolution of CO_2. The contents of the flask are then heated slowly and kept boiling until the absorbed CO_2 has been expelled. The air current connected to the tube H is allowed to asperate slowly through the apparatus during and after heating until all CO_2 has been removed from flask A. This will take an hour or more, for if the current of air does not flow slowly some CO_2 may pass through the absorption bulb S without being absorbed. For this reason, when working on soils rich in carbonates it is advisable to pass the gas through another bulb attached to the end of S, which contains about 5 cm^3 of barium hydrate solution diluted to the proper volume.

Without stopping the current of asperating air the upper end of bulb S is connected with the rubber tube G, which in turn is connected by means of a Y to the current of asperating air and also to a supply of neutral distilled water free from CO_2. The bulb S is now disconnected and held in a vertical position, so the liquid will flow down into the lower end of the bulb. A slight pressure on the clamp on M will quickly fill the top end of bulb S with

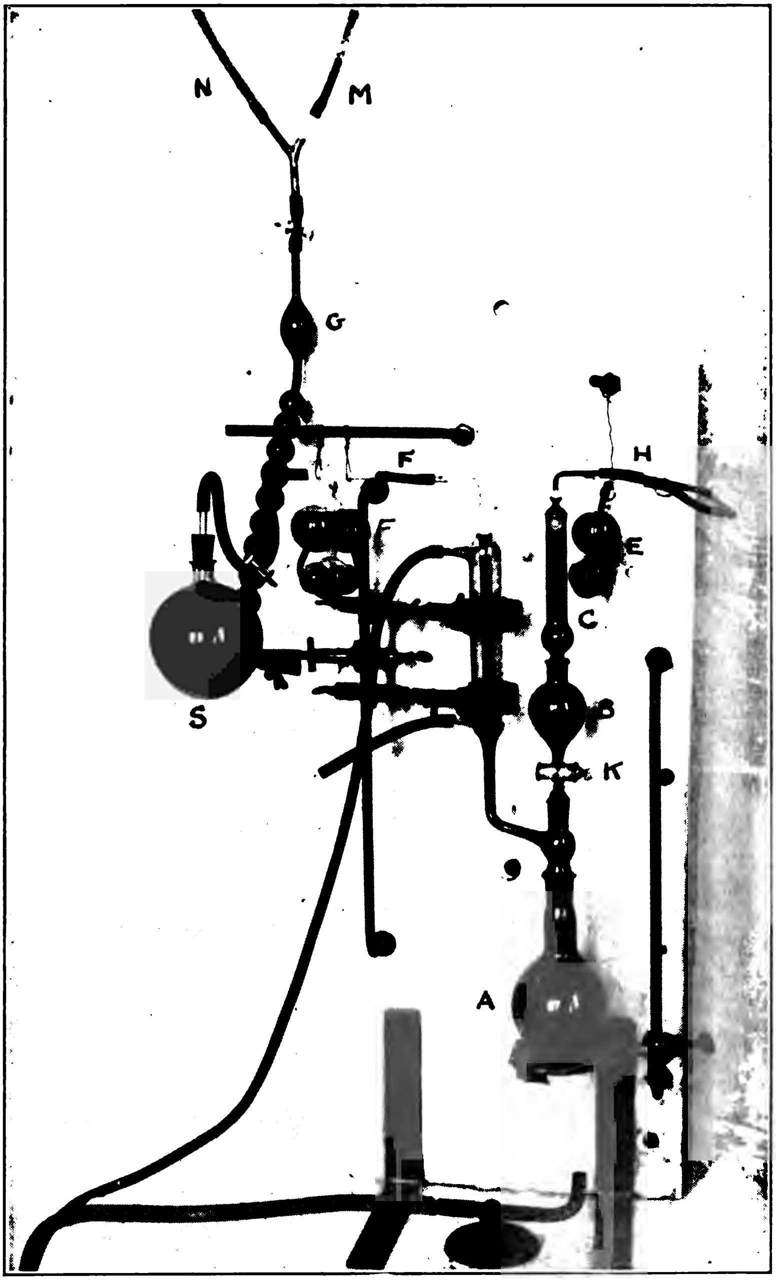
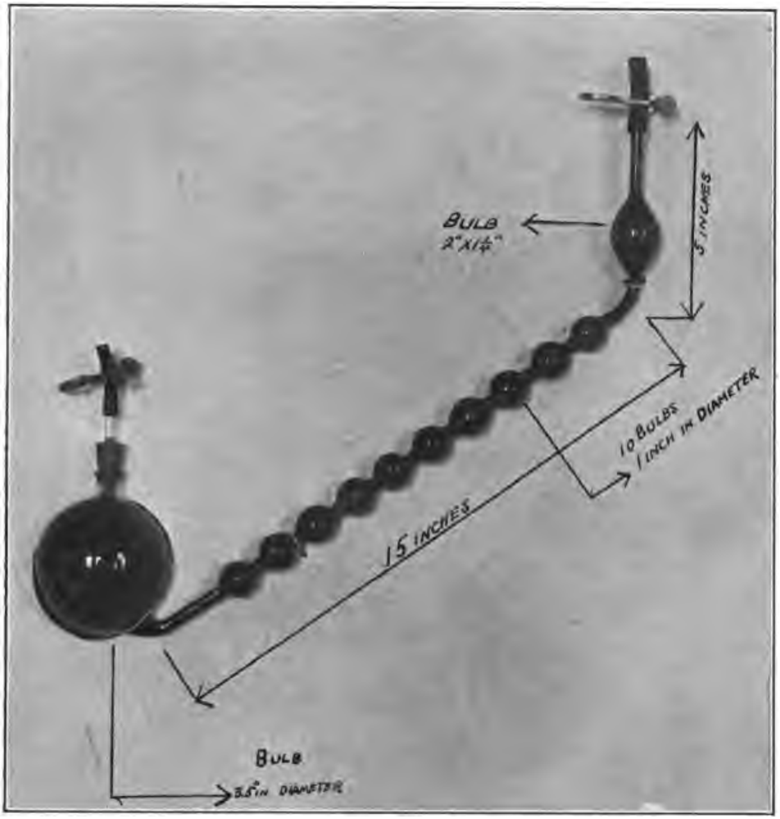

N
M
G
F
H
F
E
C
S
B
K
A

PLATE II.


BULB
2"X1¼"
5 INCHES
10 BULBS
1 INCH IN DIAMETER
15 INCHES
BULB
3.5 IN DIAMETER

wash water, which is forced rapidly through the bulb by admitting a little air through N. When the contents of the bulb have all been washed into the larger lower chamber, a few drops of phenol-phthalein are added and the excess of barium hydrate titrated with a standard oxalic acid solution (see re-agents) without removing the liquid from the bulb. This gives the quantity of barium hydrate solution neutralized by the carbon dioxide, each cubic centimeter of which represents 0.1 per cent. of CO_2.

The opening into the bulb S should be kept closed as much as possible during washing and titrating. The barium carbonate is not decomposed by the oxalic acid. The titration end point is very sharp, for the white precipitate makes the least tint of pink easily distinguishable.

Plate II shows in detail a portion of the apparatus illustrated in Plate I.

STANDARD SOLUTIONS.

Standard Potassium Permanganate Solution.—This solution is made so that each cubic centimeter will equal 0.005 grams of iron. About 5.746 grams of permanganate are dissolved in 500 to 600 cm³ of water. The solution is then boiled for 15 to 20 minutes and filtered through asbestos into a 200 cm³ graduated flask. When the solution is cool the flask is filled to the mark and the contents well mixed. After standing 24 hours or more just 500 cm³ are carefully drawn off with a dry pipette and standardized by titrating with ammonium oxalate. Six-tenths of a gram of this salt will require about 90 cm³ of permanganate solution. The weight of the ammonium oxalate used, multiplied by 0.78644, equals the corresponding weight of iron when the atomic weight of iron is taken as 55.9.

Standard Potash Solution for P_2O_5 Titration.—The strength of this solution is made so that each cubic centimeter will equal 0.01 per cent of P_2O_5 when a 5-gram sample is used for this determination. If the soil contains over one-half of 1 per cent. of P_2O_5 a smaller sample had better be used. Such a solution will contain 9.0879 grams of potash per liter, or 1.81758 grams when a 1-gram sample is used.

To prepare this solution, dissolve 75 grams of KOH in about 200 cm³ of water, transfer to a tall cylinder, add a few cubic

centimeters of a saturated solution of barium hydrate to precipitate the carbonates, cork and allow to stand for at least 24 hours before using. Filter the solution into a 5-liter graduated flask and dilute to the mark. Do not try to wash the residue out of the cylinder or on the filter.

This solution is now standardized by titrating it against an oxalic acid solution of known strength. A solution containing 10.20809 grams of oxalic acid ($C_2H_2O_4.2H_2O$) per liter will just equal a solution containing 9.08790 grams of KOH per liter. This oxalic acid solution can, however, be of any convenient strength, but should be standardized by titrating with permanganate just before using, for it slowly loses its strength.

Standard Nitric Acid Solution for P_2O_5 Titration.—This solution is made so it will just equal the KOH solution and will then contain 10.207 grams of nitric acid per liter. It takes about 13 cm^3 of the ordinary nitric acid of 1.42 specific gravity per liter to make a solution of this strength. It is standardized by titrating it against the KOH solution. It is slowly decomposed by sunlight, and should be kept in light-proof bottles. When thus protected it will maintain its strength for many months.

Standard Oxalic Acid.—This acid must be free from oxalates if solutions of it are standardized with permanganate. The acid crystals contain too much hydroscopic moisture to secure any definite quantity of them by weighing. If exposed any length of time to the air or dried artificially some combined water is driven off, which also prevents their being weighed. The permanganate method of standardizing is by far the most accurate and shortest of any of the methods.

To prepare the C. P. crystals of this salt, dissolve about 500 grams of the ordinary acid crystals in hot water, add a few cubic centimeters of sulphuric acid and allow the solution to cool very slowly, so the crystals will be a good size. The mother liquor is decanted off, the crystals washed a couple of times by decantation and then re-dissolved and re-crystallized. After the fourth crystallization the crystals are dried quickly in a cool place and transferred at once to an air-tight bottle, which is kept in subdued light.

This acid must be purified in an atmosphere free from ammonia fumes, which it will quickly absorb. The crystallizing dishes should be kept in large dessicators during the crystallizing.

Ammonium Oxalate.—$(NH_4)_2C_2O_4.H_2O$.–142.16. The pure salt can be prepared by re-crystallizing some of the ordinary C. P. salt secured in the market. This is done in the same manner as given above for oxalic acid, except no sulphuric acid is added. These crystals are also kept in air-tight bottles.

Barium Hydrate Solution for CO_2 Determinations.—This solution is made of such a strength that each cubic centimeter corresponds to 0.1 per cent. of CO_2 when a 5-gram sample is used. Such a solution will contain 35.8547 grams of $Ba(OH)_2$ $.8H_2O$ per liter, or equals 5 grams CO_2 per liter

To prepare this solution, transfer about 120 grams of the C. P. barium hydrate to a liter flask containing just 3 liters of water. This flask is kept closed with a rubber stopper, and after the barium hydrate has dissolved, the contents of the flask are thoroughly mixed by shaking. When the barium carbonate has settled 250 cm³ are drawn off with a dry pipette and used to determine the strength of this solution by titrating against an oxalic acid solution that has been prepared for this purpose and the strength of which is known. The volume of water required to dilute the 2750 cm³ so they will be of the same strength as the oxalic acid solution is thus secured. The chances of any CO_2 being absorbed are thus reduced to a minimum.

Oxalic Acid Solution for CO_2 Determinations.—An oxalic acid solution containing 14.32364 grams of oxalic acid per liter will just equal a solution containing 35.8547 grams of barium hydrate per liter, or is equal to 0.01270455 grams of iron per cubic centimeter when titrated with permanganate solution. To prepare this solution, transfer about 30 grams of oxalic acid to a 3-liter flask containing just 2 liters of water which is free from CO_2. Twenty-five cubic centimeters of this solution are drawn off with a dry pipette, transferred to an Erlenmeyer flask, 5 cm³ of sulphuric acid and about 75 cm³ of hot water added, and then titrated with standard permanganate solution. The quantity of water needed to dilute this solution so each cubic centimeter will

contain 0.01432364 grams of oxalic acid is thus secured. The water used in preparing these solutions must be free from CO_2.

Factors:

Oxalic acid by 2.5033 equals barium hydrate.
Oxalic acid by 0.34907 equals carbon dioxide.
Oxalic acid by 0.886964 equals iron.
Barium hydrate by 0.13944 equals carbon dioxide.

REAGENTS.

Ferric Nitrate Solution.—A 10 per cent. solution of this reagent is prepared by dissolving the required weight in distilled water. This solution must be free from both manganese and phosphorous.

Platinum Chloride.—To prepare this solution, dissolve 10 grams of platinum chloride in 100 cm^3 of water. The combined weights of both the sodium and potassium sulphates or chlorides multiplied by 17 will give the number of cubic centimeters of this solution needed to convert these alkalies into platinates.

Silver Nitrate Solution.—This solution contains 2 grams of silver nitrate per liter. It is kept in a lightproof bottle.

Alcohol.—The alcohol used to prepare this solution must be free from ammonia and have a gravity greater than 0.86. It is prepared by diluting 5 volumes of 95 per cent. alcohol with 1 volume of water. This diluted solution should have a gravity of 0.86, and should always be tested with a hydrometer before using, for the ordinary 95 per cent. alcohol is seldom this strong.

Molybdic Acid Solution.—To prepare this solution, transfer 100 grams of molybdic acid to an 800 cm^3 beaker and add just enough water to make a paste of the acid. This paste is dissolved in 80 cm^3 of strong ammonia (0.90 gravity), and when in solution diluted with 400 cm^3 of water. No molybdic acid is precipitated out of this solution on standing, consequently it is kept as a stock solution from which the molybdic acid used to precipitate the phosphorus is prepared by slowly pouring 240 cm^3 of this solution into 500 cm^3 of cold, dilute nitric acid

(150 cm^3 of HNO_3 .gr. 1.42, to 350 cm^3 of water). The nitric acid should be stirred vigorously during this mixing and kept as cool as possible. This latter solution is then heated to and kept at about 75° to 80°C. for two hours, during which time more or less molybdic acid is thrown out of solution that might separate out with ammonium phospho-molybdate precipitate. This solution should stand for 24 hours before using.

June, 1913.

INDEX.

A

B

C

D

L

M

N

O

P

R

S

GEOLOGICAL SURVEY OF NEW JERSEY

HENRY B. KÜMMEL, STATE GEOLOGIST

BULLETIN 11.

THE MINERAL INDUSTRY OF NEW JERSEY FOR 1912

BY

M. W. TWITCHELL, Ph. D.

Assistant State Geologist

TRENTON, N. J.

MacCrellish & Quigley, State Printers.

1913.

Letter of Transmittal.

TRENTON, August 25th, 1913.

The State Printing Board, Trenton, N. J.:

GENTLEMEN—I hereby request that the State Printing Board order the publication of 2,700 copies of a Bulletin on the Mineral Industry of New Jersey for 1912, the manuscript of which is transmitted herewith. The publication of this report has been approved by the Board of Managers of the Geological Survey, and favorable action by the State Printing Board is requested, as provided by Chapter 46, Laws of 1910. The printing contract for 1912–1913 provides for the publication of such Bulletins of the Geological Survey as shall be ordered by your Board.

The Bulletin shows that the Mineral Industry of New Jersey during 1912 had a value of $40,391,548. This was $2,675,137 more than in 1911, and was greater than ever before in the history of the industry.

Very respectfully,

HENRY B. KÜMMEL,
State Geologist.

The Mineral Industry of New Jersey.

BY M. W. TWITCHELL.

GENERAL SUMMARY.

As in 1910 and 1911, the statistics of the mineral production of New Jersey for the calendar year 1912 were collected by the Geological Survey of New Jersey in co-operation with the United States Geological Survey. This method avoids the necessity of troubling producers by requests from two organizations, and insures greater accuracy and completeness in the results.

The total value of the mineral production in New Jersey in 1912 was $40,391,548. This is $2,675,137 more than in 1911. It is distributed among the different industries as follows:

VALUE OF THE MINERAL INDUSTRY IN 1912.

	Value.	*Increase or Decrease Compared to 1910.*
Zinc Mining,	$9,626,191[a]	$797,410 I
Iron Mining,	1,192,816	35,545 I
Clay and Clay-working Industries,	20,540,561	1,703,458 I
Stone,[b]	1,738,473	114,589 I
Sand and Gravel,	1,146,640	87,714 I
Portland Cement,	3,052,098	207,430 D
Lime,	65,241	48,543 D
Mineral Water,	209,726	397 D
Sand-lime Brick,	6,924	10,786 D
Mineral Paints, / Coke and By-products,	2,812,424[d]	205,154 I
Miscellaneous,[c]	454	....
Total,	$40,391,548	$2,675,137 I

[a] Value of recoverable output figured as metallic zinc.
[b] Includes Slate and Talc.
[c] Includes Greensand Marl and Gems.
[d] Combined in order to conceal the output of individual producers.

DISTRIBUTION OF ACTIVE MINERAL INDUSTRIES.

The distribution of the *active* mineral industries in New Jersey in 1912 is shown on the accompanying map (Plate 1). Only mines, quarries, pits and works actually in operation and reporting a production during 1912 are shown. At quite a number of places more plants exist than could be shown. This is especially true of Trenton, where there are thirty-four pottery manufacturers, some having several plants.

The distribution of these industries presents a number of features of interest.

The only operating *Zinc* mines are near Franklin Furnace, Sussex County. The active *Iron* mines are in the Highlands and extend from near Ringwood, Passaic County, by way of Hibernia and Dover in Morris County, to Oxford Furnace, near Belvidere, in Warren County.

Limestone is quarried in Sussex, Warren, Morris and Hunterdon Counties. *Slate* is quarried at only two points, both in Sussex County. The *Trap-rock* quarries are chiefly in the Triassic area, and are scattered along the ridges, including the Palisades, the Watchung Mountains, Rocky Hill, etc. The *Granite* quarries are in the Highlands, chiefly around Pompton, Passaic County; Waterloo, Sussex County, and Boonton, German Valley and Hibernia, Morris County. The *Sandstone* quarries are chiefly in the Triassic area, especially near Stockton, Byram, Princeton and Wilburtha. The only *Talc* and *Soapstone* quarry is near Phillipsburg.

Most of the *Clay* pits and clay-working plants are located along the Cretaceous belt extending from Woodbridge, Middlesex County, to Salem, in Salem County, although quite a number are scattered over the rest of the State.

All of the operating *Portland Cement* plants are in Warren County, near Phillipsburg. The only *Coke* works reporting is located at Camden. The *Sand-lime Brick* works are at West Palmyra, Burlington County, Penbryn and Haddonfield, Camden County, and Rockaway, Morris County. The *Mineral-paint* plants are at Newark, Essex County, Lincoln, Middlesex County, and Grasselli, Union County.

The *Sand and Gravel* pits are widely distributed throughout the State, though the majority are located in the southern part. In 1912, there were pits in sixteen out of the twenty-one counties, Essex, Hudson, Hunterdon, Salem and Somerset being the only ones not reporting a production. Of the 95 producers, 21 were in Burlington, 17 in Middlesex, 10 in Cumberland, 8 in Gloucester, 7 in Camden, 6 in Morris, 5 in Sussex, 4 in Bergen, 3 each in Warren, Passaic and Cape May, 2 each in Union, Monmouth and Mercer, and 1 each in Atlantic and Ocean.

Metallic Ores.

ZINC.

The mines at Franklin Furnace and Ogdensburg, Sussex County, both controlled by the New Jersey Zinc Company, are the only zinc mines in the State. During 1912, as for several years past, the Franklin Furnace mine was the only one operated, although some development work was done upon the Ogdensburg property. The Franklin Furnace mine is one of the most important zinc mines in the United States, its production alone being sufficient to place New Jersey *first* as a producer of zinc among the Eastern or Appalachian States and *second* in the United States, the leading State being Missouri.

The figures for New Jersey are given in the following table, which also includes those of the other Eastern or Appalachian States for comparison:

MINE PRODUCTION OF ZINC IN THE EASTERN OR APPALACHIAN STATES IN 1912.a

State.	*Ore Mined (Short Tons).*	*Zinc Production (figured as spelter in pounds).*	*Value.*
New Jersey, ...	459,585	139,510,008	$9,626,191
New York, ...	b	28,000	1,932
North Carolina, ...	b	283,320	19,549
Tennessee, ...	b	4,381,300	302,310
Virginia, ...	b	497,235	34,309
Total, 1912, ...		144,699,863	$9,984,291
Total, 1911, ...		159,351,558	$9,083,039

(a) Modified from table compiled by Mr. H. D. McCaskey of the U. S. Geological Survey.

(b) Mine production of zinc ore not available. In 1911 the ore production of Tennessee was 22,564 tons; and the combined production of Virginia and New York, including lead-zinc ores, was 16,704 tons; while that of New Jersey was 374,064 tons.

There was a decrease in the New Jersey production from 154,890,900 pounds (all figured as spelter) in 1911 to 139,510,008 pounds in 1912; but because of higher prices, the value increased from $8,828,781 in 1911 to $9,626,191, a gain of $797,410.

The quantity of ore hoisted during the year 1912, as reported by the New Jersey Zinc Company, was 411,489 tons, while according to figures furnished by the U. S. Geological Survey the quantity of ore sold or treated was 459,585 tons, 363,588 tons being treated in the concentrating mills and 95,997 tons sold in the crude state.

According to C. E. Siebenthal, of the U. S. Geological Survey, the actual production of zinc (or spelter) from New Jersey ores in 1912 was 16,941 tons, or 23,882,000 pounds. This was probably smelted in the smelter of the New Jersey Zinc Company at Palmerton, Pennsylvania, which has a capacity of 5,772 retorts. On the basis of the 1912 figures, New Jersey ranks fourth in the production of spelter. A large part of the output of the New Jersey zinc mines has, as a rule, been made into zinc white, or zinc oxide, at the plant of the New Jersey Zinc Company at Newark, but no production of zinc white at this plant is reported by this company for the year 1912.

ZINC ORE MINED IN NEW JERSEY SINCE 1880.

Previously reported,	4,504,784 tons
Mined in 1912,	411,489 "
Total,	5,116,273 tons

IRON.

The iron ore mined in the United States in 1912 amounted to the great total of 55,150,147 long tons, compared with 43,876,552 tons mined in 1911, an increase of 11,273,595 tons, or 25.69 per cent., according to an advance statement by Ernest F. Burchard, of the United States Geological Survey. The following table gives the quantities of iron ore mined in the ten leading States in 1912 in long tons:

IRON ORE PRODUCTION BY STATES, 1912.

Rank.	State.	1912.
1	Minnesota,	34,431,768
2	Michigan,	11,191,430
3	Alabama,	4,563,603
4	New York,	1,216,672
5	Wisconsin,	860,600
6	Pennsylvania,	517,081
7	Virginia,	446,305
8	Tennessee,	416,885
9	New Jersey,	364,673
10	Georgia,	134,637
	Total (ten States),	54,143,654
	Other States,[1]	1,006,493
	Total (U. S.),	55,150,147

There was no marked change in the condition of the iron-mining industry in New Jersey in 1912. There was a decrease in the amount of iron ore mined of 101,561 long tons, as compared with 1911, but an increase in the amount marketed of 7,102 long tons and an increase in the value of the amount marketed of $34,545.

In last year's statement in regard to the iron-mining industry (Bulletin 7 of the N. J. Geological Survey, p. 8) the "production" for 1911 was given as 359,721 long tons. This was a mistake, as the actual production, or ore mined, was 466,234 long tons, and the figure given, 359,721 long tons, was the amount of ore marketed. One result of taking the "production" at 359,721 tons was to emphasize the apparent decrease in 1911 as compared with 1910. The actual decrease in ore mined was only 55,598 tons, instead of 162,111 tons.

The following table gives the details of the iron-ore production for 1912, together with the totals for 1911 for comparison:

IRON ORE PRODUCTION IN NEW JERSEY IN 1912.

County.	*Active Producers.*	*Ore Mined*[2] *(long tons).*	*Ore Marketed*[2] *(long tons).*	*Value of Ore Marketed.*	*Stock on Hand Dec. 31, 1912, (long tons).*
Morris,	6	163,389	186,038	$609,013	867
Passaic and Warren,	3	201,284	180,785	583,803	121,779
Total, 1912,	9	364,673	366,823	$1,192,816	122,646
Total, 1911,[3]	10	466,234	359,721	$1,158,271	124,080

[1] Including the 17 other States that reported a production in 1912.

[2] Nearly all magnetite.

[3] The figures for 1911 have been somewhat revised since they were published last year.

Morris County continued to be the largest producer, its total of ore mined in 1912 being 163,389 long tons; while the combined output of Passaic and Warren Counties was 21,284 tons. There were nine active mines, six in Morris, two in Warren and one in Passaic County. The distribution of these mines is given on Plate I.

The Washington mine at Oxford, Warren County, was the largest producer in 1912, displacing the Richard, at Wharton, Morris County, which was second. The Peters, at Ringwood, Passaic County, was third. The other active mines were the Wharton, at Hibernia, Mt. Hope, at Mt. Hope, Hoff, at Wharton, and High Ledge, at Ledgewood, in Morris County; and the Ahles, at Oxford, Warren County.

IRON ORE MINED IN NEW JERSEY SINCE 1870.

Previously reported (with correction for 1911),	19,450,294 tons
Mined in 1912,	364,673 "
Total,	19,814,967 tons

SPECIAL STATISTICS REGARDING THE IRON-MINING INDUSTRY IN NEW JERSEY IN 1909.[1]

Number of operators,	8
Number of mines,	10
Capital,	$3,612,024
Expenses of operation and development,	$1,321,915
This is distributed as follows:	
Services—	
Salaried officers and clerks,	66,049
Wage earners,	840,967
Miscellaneous—	
Supplies,	199,707
Fuel and rent of power,	168,368
Royalties and rent of mines,	7,091
Taxes,	7,350
Rent of offices and other sundry expenses,	32,383
Value of product,	$1,651,091
Persons engaged in industry,	2,148
This is distributed as follows:	
Proprietors and salaried officers and clerks,	53
Wage earners (Dec. 15th or nearest representative day),	2,095

[1] Modified from tables in 13th Census of the United States, supplement for New Jersey, published in 1913 on figures for 1909.

Land controlled, acres,	13,668
Owned,	5,169
Held under lease,	8,499
Primary horse-power,	6,585

ELECTRIC SMELTING OF IRON ORES.

Much has been said and written in recent years regarding the direct smelting of iron ores in the electric furnace. In "Mineral Resources of the United States for 1911," the U. S. Geological Survey gave an interesting resumé of the experiments so far conducted along this line. The following brief extract from this article summarizes the situation at the present time:

"Kershaw in the Iron Trade Review for January, 1912, gives a tabular summary of comparative costs of electrically produced pig iron, which is given below, with the addition of dates":

Comparative Costs of Electrically Produced Pig Iron.

Date.	*Type of Furnace.*	*Location.*	*Power Kilowatt Hours.*	*Estimated Cost (2,204 pounds).*	*Notes.*
1903	Stassano,	Darfo, Italy,	2,866	$18.60	Power at $9 per electric horse-power year.
1904	Keller,	Livet, France,	2,589	13.27	
1906	Heroult,	Sault St. Marie, Canada,	1,642	11.77	Power at $10.71 per electrical horse-power year; ore at $1.50 per ton.
1908	Gronwall,	Trollhättan, Sweden,	1,957	13.56	Estimate based on early trials.
1910	"	Trollhättan, Sweden,	1,735	13.00	Actual results obtained at Trollhättan, Sept. 3, 1911.
1910	Heroult,	Heroult, Shasta Co., Cal.,	....	15.00	Power at $12 per electrical horse-power year; ore $1.50 per ton.

"With regard to the future of electric smelting of pig iron there are certain controlling factors that will doubtless limit it to localities like Trollhättan and Heroult where all physical and commercial conditions are favorable to its development. The main point seems to be that the saving in coke effected by the use of electric heating is so small that electric power must be produced or sold at a cost of $8 to $10 per electrical horse-power year, a figure far below the possibilities of the great majority of hydroelectric power stations at present. The electric process is also further handicapped by the cost of carbon electrodes, an expense which the ordinary blast furnace does not have to bear. These conclusions, it should be noted, have no bearing on the refining of steel in the electric furnace, a practice which is already established, and is rapidly expanding in Europe and America."

PIG IRON AND STEEL.

According to figures furnished by the Bureau of Statistics of the American Iron and Steel Institute, New Jersey produced 36,876 long tons of pig iron (including ferro alloys) in 1912. This amount is not included in the State total given elsewhere as it would involve a duplication of a part of the value already given for iron ore production.

According to the same authority as that mentioned above, New Jersey produced the following amounts of pig iron of all kinds from 1908 to 1912:

PRODUCTION OF PIG IRON IN NEW JERSEY, 1908–1912.

1908,	225,372 long tons.
1909,	294,474 " "
1910,	264,781 " "
1911,	40,663 " "
1912,	36,876 " "

According to figures furnished by the Bureau of Statistics of the American Iron and Steel Institute, New Jersey produced the following amounts of all kinds of finished rolled iron and steel from 1908 to 1912:

PRODUCTION OF ROLLED IRON AND STEEL IN NEW JERSEY, 1908 TO 1912.

1908,	147,347 long tons.
1909,	188,256 " "
1910,	165,057 " "
1911,	154,563 " "
1912,	175,143 " "

As it would involve a duplication of values, this amount is not included in the State total.

COPPER.

None of the copper mines in this State reported any production in either 1911 or 1912.

THE PAHAQUARRY MINE.

The efforts which have been under way for several years to develop the Pahaquarry mine, near Dunnfield, Warren County, were continued. In 1911 the mine was operated for three months and the 200-ton concentrating mill for two months, but no concentrates were shipped. The ore mineral, chalcocite, was reported to break too fine for profitable extraction by the process used, and losses were considerable. Experiments were being made to improve the saving.[1] It was recently reported that during 1912 a large plant for roasting and leaching the low grade ore was completed.[2]

[1] Mineral Resources of the United States for 1911, Part 1, p. 881.
[2] Mineral Resources of the United States for 1912, Advanced Chapter.

Non-Metallic Minerals and Products.

CLAY AND CLAY-WORKING INDUSTRY.

The total value of the products of the clay and clay-working industry of New Jersey passed the $20,000,000 mark in 1912. The exact figures are $20,540,561; of which $19,838,553 is the total for clay products, and $702,008 the total for raw clay mined and sold by the miner. As the corresponding figures for 1911 were raw clay, $658,875, clay products, $18,178,228, and grand total $18,837,103, a substantial increase is shown. The total increase over the figures of 1911 is $1,703,458, of which $43,133 was in raw clay mined and sold and $1,660,325 was in manufactured clay products.

The following table gives the rank of the five leading States in the manufacture of clay products in 1911:

PRODUCTION OF CLAY PRODUCTS BY LEADING STATES, 1911.

State.	*Rank.*	*No. of Operators.*	*Value.*	*Percentage of Total Product.*
Ohio,	1	633	$32,663,895	20.13
Pennsylvania,	2	423	20,270,033	12.49
New Jersey,	3	162	18,178,228	11.21
Illinois,	4	330	14,333,011	8.83
New York,	5	222	10,184,376	6.28
Total,			$95,629,543	58.94
All other producing States,			66,606,638	41,06
Total (United States),			$162,236,181	100.00

From the above table it will be seen that New Jersey is one of the foremost States in the manufacture of clay products. With 48 States reporting an individual production varying from over $32,000,000 down to less than $30,000, New Jersey ranks third, being exceeded only by Ohio and Pennsylvania. It will also be

noted that the average individual production of the New Jersey operators was much greater than that of any other State.

In 1911 New Jersey stood first among the States in the production of raw clay, second in the total value of all pottery and fourth in the total value of all brick and tile. It ranked first in the manufacture of sanitary ware, first in china, third in white ware and third in porcelain electrical supplies. It was first in fireproofing, second in "tile, not drain," which includes roofing, floor, wall and art tile, second in architectural terra cotta, third in front brick and fourth in common brick. The chief change here over 1910 is in the advance from fifth to fourth place in the making of brick and tile. As the figures for all the States for 1912 are not yet available, comparative statements can be made for 1911 only; but it is not likely that there will be any very notable change when the 1912 figures become available.

SPECIAL STATISTICS REGARDING THE CLAY-WORKING INDUSTRIES IN NEW JERSEY IN 1909.[1]

	Pottery, Terra Cotta and Fire Clay Products.[2]	*Brick and Tile.*[2]	*Total.*
Number of establishments, ...	88	76	164
Capital, ...	$22,349,000	$7,355,000	$29,704,000
Expenses for services and materials,.	$10,248,000	$2,674,000	$12,922,000
This is distributed as follows:			
Salaries, ...	$1,036,000	$205,000	$1,241,000
Wages, ...	5,661,000	1,625,000	7,286,000
Cost of materials, ...	3,551,000	844,000	4,395,000
Value of products, ...	$13,139,000	$4,073,000	$17,212,000
Value added by manufacture, ...	$9,588,000	$3,229,000	$12,817,000
Persons engaged in industry, ...	10,542	3,619	14,161
Distributed as follows:			
Proprietors and firm-members,.	38	64	102
Salaried employees, ...	689	150	839
Wage earners, average number,	9,815	3,405	13,220
Primary horse-power, ...	11,817	11,419	23,236

[1] Modified from data published in the 13th Census of the United States, Supplement for New Jersey, published in 1913, on figures collected in 1910.
[2] Expressed to the nearest thousand.

CLAY.

Only a small part of the clay mined in New Jersey is included under this head. All that used by the miner in the manufacture of brick, tile, etc., is reported as the finished product, and only that sold by the miner is here included. For several years New Jersey has stood first, both as regards quantity and value, among the States in the production of raw clay.

The details regarding the production of clay are given in the following table:

CLAY MINED AND SOLD RAW, 1912.

	No. of Producers.	*Amt. in Short Tons.*	*Value in 1912.*	*Value in 1911.*
Ball clay,	5	2,649	$9,152	$6,433
Fire clay, including sagger clay,	37	291,474	502,053	471,695
Stoneware clay,	5	20,031	39,905	64,068
Brick clay,	8	50,186	33,168	20,326
Miscellaneous,	9	74,543	117,730	96,353
Total,	48	438,883	$702,008	$658,875

The above table shows increases in all items except brick clay, in which case there was a decrease. The total increase was $43,133.

As usual, fire clay greatly exceeded all other kinds combined. Of course, it is to be borne in mind that this means only fire clay mined and sold raw, and is compared with other clays mined and sold raw. There was also a large amount of fire clay dug and made into fire brick directly; and, on the other hand, there was probably more brick clay actually dug than fire clay, but most of it was used at once by the miner. The value of clay so dug but not sold is included elsewhere in the returns for the clay products manufactured.

Only six counties made returns of clay dug and sold. Middlesex, as usual, stood first, with a production of 383,300 tons, valued at $616,440. This constituted 87.8 per cent. of the total production. Mercer was second, 14,530 tons, value $37,870; Burlington third, 15,062 tons, value $20,587. Ocean, Camden and Cumberland follow in the order given, their total production being 25,991 tons, valued at $27,111.

POTTERY.

According to a recent report of Mr. Middleton, of the United States Geological Survey, the pottery industry of the United States "was in a high state of development during the year 1912, and the value of the pottery products marketed was the largest in the history of the industry. This was due partly to the general prosperity enjoyed by the country at large, but more especially to the steady improvement in the wares themselves in body, design and decoration. American pottery is gaining a stronger hold on the market, becoming more popular every year. Many if not most of the best hotels and clubs in the country are now using large quantities of domestic china." The total value of the production of the United States in 1912 was $36,504,164.

New Jersey continued to rank second among the States in the production of pottery, Ohio, as during the preceding year, standing first. The total value of New Jersey's production in 1912 was $8,935,920. This was $533,979 more than in 1911 and $347,465 more than in 1910. Of the total production of the United States, the output of New Jersey constituted 24.47 per cent., or practically one-fourth.

The following table giving the pottery production of the ten leading States in 1912 brings out more clearly the position of New Jersey as one of the leading States:

POTTERY PRODUCTION OF THE TEN LEADING STATES IN 1912.(b)

Rank.	State.	Active Producers	Red Earthenware.	Stoneware and Yellow ware, Etc.	White-ware, Etc.	China, Etc.	Sanitary Ware.	Porcelain Electrical Supplies.	Miscellaneous.	Total.	Percentage of Total.
1	Ohio,	106	263,085	1,832,266	9,969,491	....	451,971	1,827,290	1,164,632	15,508,735	42.49
2	New Jersey,	52	36,655	48,297	1,090,683	1,155,766	5,199,278	1,146,467	258,774	8,935,920	24.48
3	West Virginia,	14	....	(a)	2,051,987	50,002	1,156,478	(a)	36,444	3,365,166	9.22
4	New York,	24	31,497	(a)	(a)	691,065	(a)	1,269,108	51,988	2,405,532	6.59
5	Pennsylvania,	29	162,137	281,526	902,585	280,472	185,000	307,636	9,184	2,128,540	5.83
6	Indiana,	10	(a)	46,100	(a)	....	633,578	(a)	....	1,077,102	2.95
7	Illinois,	24	35,827	675,244	(a)	....	(a)	(a)	23.812	931,951	2.55
8	Massachusetts,	12	163,010	26,300	(a)	....	....	(a)	12,789	252,099	.69
9	California,	12	36,091	54,087	(a)	....	(a)	(a)	6,126	219,653	.60
10	Michigan,	6	99,555	....	(a)	....	....	(a)	(a)	194,892	.53
	Total (10 States),	289	827,857	2,963,820	14,014,746	2,177,305	7,626,305	4,550,501	1,563,749	35,019,590	95.93
	Other States, (c)	145	130,413	955,958	814,685	....	275,950	376,815	226,060	d1,484,554	4.06
	Total (U. S.),	434	958,270	3,919,778	14,829,431	2,177,305	7,902,255	4,927,316	1,789,809	36,504,164	100.00

(a) Included in "Other States" and State totals.
(b) This table is modified from one published by the United States Geological Survey.
(c) Includes products made by less than three producers.
(d) Made up of State totals of the States not named above.

The principal pottery product of New Jersey is sanitary ware, and in this, as is evident from the above table, this State stands first. The total value of the sanitary ware produced by the United States in 1912 was $7,902,255, and of this New Jersey's portion was $5,197,278 or 65.76 per cent.

The following table gives the different kinds of pottery, with the amount of each kind produced in New Jersey in 1912. The figures for 1911 are also given, for the sake of comparison:

POTTERY PRODUCTION BY VARIETIES, 1912.

	No. of Producers Reporting.	1911.	1912.	Increase or Decrease.
Red earthenware,	7	$38,910	$36,655	$2,255 D.
Stoneware and yellow or Rockingham ware,	3	75,915	48,297	27,618 D.
White ware, including C. C. ware, white granite, semi-porcelain ware and semi-vitreous porcelain ware,	10	1,148,904	1,090,683	58,221 D.
China, bone china, delft and belleek ware,	8	1,105,278	1,155,766	50,488 I.
Sanitary ware,	20	4,898,588	5,199,278	300,690 I.
Porcelain electrical supplies,	12	913,921	1,146,467	232,546 I.
Miscellaneous,[1]	11	220,425	258,744	38,349 I.
Total,		$8,401,941	$8,935,920	$533,979 I.

As will be seen from the above table, there were decreases in the value of red earthenware, stoneware and yellow ware and white ware; but gratifying increases in china, sanitary ware, porcelain electrical supplies and miscellaneous products.

The production of the leading counties is as follows:

POTTERY PRODUCTION BY COUNTIES, 1912.

Rank.	Counties.	No. of Producers Reporting.	Value.	Per Cent.
1	Mercer,	33	$8,069,694	90.30
2	Middlesex,	5	353,285	3.95
3	Camden,	3	242,973	2.72
4	Hunterdon,	3	173,998	1.94
	All other counties,[1]	..	85,970	.96
	Total,		$8,935,920	

[1] Includes chemical ware, art pottery, clay tobacco pipes, doorknobs, porcelain hardware trimmings and druggists' earthenware.

As is evident from this table, Mercer County not only stands first in the production of pottery, but its output is over 90 per cent. of the State total. As all of the Mercer County potteries are located at Trenton, the production given, $8,069,694, is that of Trenton alone, making it one of the two leading pottery centers of the United States, East Liverpool, Ohio, being the other. Parkersburg, West Virginia, is coming to the front as another leading center; and will be assisted materially if the General Porcelain Company of East Liverpool carries out its recently announced intention of moving its seven plants to Parkersburg and there consolidating them into one large plant.

Middlesex County, with two new producers, increased its production by $153,597 over the previous year, and moved from third to second place. Camden and Hunterdon were the third and fourth of the leading counties. Besides the four leading counties just mentioned, pottery was produced by Union, Essex, Burlington, Monmouth, Cumberland and Atlantic Counties, in the order given; the value of the total output of these counties being $85,970.

Of the different classes of pottery, Mercer County produced all of the white ware and china, all of the sanitary ware except to the value of $536,510, and by far the larger portion of the porcelain electrical supplies. Hunterdon County continued to lead in the manufacture of stoneware and yellow ware, and Essex County in red earthenware. Camden County held its place as second in sanitary ware, with Middlesex third. Hunterdon was the only county beside Mercer which produced any porcelain electrical supplies.

BRICK AND TILE.

The brick and tile industry was in a prosperous condition in 1912. The total value of the New Jersey production was $10,-902,633, which was $1,126,346 more than in 1911 and $1,656,779 more than in 1910.

[1] Less than three producers each, or the amount is so small that the output of individual operators is actually or approximately revealed.

The statistics regarding the manufacture of brick and tile in 1912 are summarized in the following table:

PRODUCTION OF BRICK AND TILE BY VARIETIES, 1912.

	Counties.	*No. of Producers.*	*Production in Thousands.*	*Value.*	*Aver. value per M.*	*Increase or Decrease.*
Common brick, ...	19	65	429,309	$2,592,091	$6.04	$190,129 I
Front brick, ...	7	11	48,852	558,372	11.43	27,348 I
Fancy brick, ...	2	2	......	384,169	....	47,949 D
Enameled brick, ...	1	2				
Fire brick, ...	3	13	60,782	1,460,988	24.03	116,104 I
Total brick, ...				$4,995,620		$285,632 I
Drain tile, ...	5	8	......	50,984	....	24,482 I
Architectural terra cotta, ...	3	6	......	2,330,065	....	660,092 I
Fireproofing and hollow blocks, ...	4	12	......	2,031,350	....	302,539 I
Tile (not drain), ...	3	14	......	1,255,246	....	57,916 I
Miscellaneous,[1]	4	9	......	239,368	....	204,315 D
Total all products, ...				$10,902,633		$1,126,346 I

It will be noted that there were increases in all classes of brick and tile except fancy and enameled brick and some of the miscellaneous products. The greatest increases were in architectural terra cotta ($660,092) and fireproofing and hollow blocks ($302,539). The increased use of fireproofing and hollow blocks has been one of the most significant features in the clay working industries throughout the country in the last few years. The value of burned clay products as fireproof building material is being realized more and more, and their use is steadily increasing. In connection with the increased use of hollow block, the following statement by Mr. Joseph Middleton, of the United States Geological Survey, is of interest: "The decrease in the common-brick output[1] may be partly accounted for by the increased use of hollow block or tile for the construction of large buildings and even of dwelling houses. This form of construction offers many advantages, among which are economy in con-

[1] Includes sewer pipe, stove lining, glass-house pots, gas-furnace linings, conduits, gas logs, wall coping and flue lining. Last year sewer pipe was listed separately.

[1] There was a decrease in the output of common brick for the whole country in 1911.

struction, the ease and rapidity with which it can be put in the wall, and its non-conductivity. All of these should be factors in the extension of its use. Structures made of hollow tile may be faced with either brick, stucco or other material. It seems, therefore, likely that the production of common brick will not show rapid increase in the future, and it is probable that the use of hollow tile or block will largely increase."[2]

The production of brick and tile in the leading counties was as follows:

PRODUCTION OF BRICK AND TILE BY COUNTIES, 1912.

Rank.	*Counties.*	*Producers.*	*Value.*	*Per cent.*
1	Middlesex,	37	$8,062,219	73.69
2	Mercer,	11	703,353	6.45
3	Monmouth,	9	510,314	4.68
4	Somerset,	3	332,423	3.04
5	Bergen,	10	307,913	2.82
6	Camden,	4	257,877	2.36
7	Burlington,	8	167,868	1.54
8	Atlantic	4	132,579	1.21
	All other counties,[1]		428,087	3.92
	Total,		$10,902,633	

Middlesex County retained its pre-eminent position in the production of brick and tile, its thirty-seven producers making over three-fourths of the total output of the State. Mercer County was again second, though its production was far below that of Middlesex. Monmouth, which was fifth in 1911, became third; Somerset changed from sixth to fourth place, and Burlington moved forward from eighth to seventh place; on the other hand, Bergen, Camden and Atlantic showed decreases, and changed positions from third, fourth and seventh to fifth, sixth and eighth respectively.

Common brick were manufactured in all counties of the State except Cape May, Essex and Sussex. Middlesex stood first, the value of its output being $1,282,407; Bergen second, $307,913; Monmouth third, $178,628, displacing Mercer, which became fourth, with an output of $165,418; then Burlington ($140,718).

[2] Mineral resources of the United States for 1911, Part II, p. 521.

[1] In these counties there are either less than three producers, or the amount is so small that the output of individual operators would be actually or approximately revealed if separately given.

Camden ($134,189), Atlantic ($88,376) and Passaic ($73,500). There were 64 producers who reported making common brick.

Front brick were produced by Middlesex, Camden, Atlantic, Mercer, Morris, Monmouth and Cumberland Counties, in the order given, but separate figures for the counties cannot be given, because in each case there were less than three producers.

Fancy and enameled brick were made in Middlesex and Camden counties, the former being the greater producer.

Fire brick were produced in Middlesex, Hudson and Mercer counties; the production of Middlesex amounting to $1,283,668, an increase of $128,976, and constituting 87.80 per cent. of the total output of the State.

The total value of the drain tile produced was $50,984, which was about twice that of the previous year. The producing counties were Middlesex, Salem, Monmouth, Burlington and Camden, in the order given.

Middlesex produced 86.47 per cent. of the architectural terra cotta, its product having a value of $2,014,842; the other producing counties, in order, being Somerset and Burlington.

By far the larger part of the fireproofing was also made in Middlesex County, its product having a value of $1,818,241, an increase of $209,976. The other producing counties were Monmouth, Burlington and Warren, in the order given.

Tile (not drain) were made in Middlesex, Mercer and Monmouth counties, the value being $664,848, $464,899 and $125,-499, respectively.

Sewer pipe, stove linings, glass-house pots, gas-furnace linings, conduits, gas logs, wall coping and flue lining constitute the group of miscellaneous products; their total value being $239,-368. The sewer pipe was made in Middlesex and Atlantic counties, the glass-house pots in Cumberland, the gas-furnace linings in Mercer, and the conduits, stove linings, gas logs, wall coping and flue linings in Middlesex. There was a decided decrease in the amount of sewer pipe made. In 1911 there were four producers, and the value of the output was published as a separate item as $103,137; while in 1912 there were only two producers, and the amount is included among the miscellaneous products.

STONE.

The production of stone has been an important industry in the State for many years. The chief product is crushed stone for various purposes, especially road metal. In 1912 crushed stone constituted 77.71 per cent. of the total stone output. Trap rock is the chief variety quarried, forming 69.16 per cent. of all stone produced in 1912 and 85.63 per cent. of the crushed stone. Although the value of the building and monumental stone for 1912 was only $157,042, and it constituted only 9.03 per cent. of the total stone production, there was an increase of $24,029 over that of 1911 and of $56,704 over that of 1910, an encouraging evidence of steady growth along this line. The total stone production for 1912 was valued at $1,738,473, while that of 1911 was $1,623,884, an increase of $114,589.

The production of stone for 1912 by varieties and by uses is given in the following tables:

PRODUCTION OF STONE BY VARIETIES, 1912.

	Value.	*Per cent.*
Trap,	$1,202,397	69.16
Limestone,	205,334	11.81
Sandstone,	166.583	9.58
Granite,	142,515	8.19
Slate, Talc and Serpentine,	21,644	1.24
Total, 1912,	$1,738,473	100.00
Total, 1911,	1,623,884	

PRODUCTION OF STONE BY USES, 1912.

	Value.	*Value.*	*Per cent.*
Building stone and monuments,	....	$157,042	9.03
Rough,	$106,927	....	....
Dressed,	50,115	....	....
Paving,	....	32,571	1.87
Crushed stone,	....	1,341,046	77.71
Road metal,	679,768	....	....
Railroad ballast,	266,136	....	....
Concrete,	395,142	....	....
Blast furnace flux,	....	122,943	7.07
Agricultural,	....	24,329	1.39
Other uses,[1]	....	60,542	3.48
Total, 1912,		$1,738,473	100.00
Total, 1911,		1,623,884	

[1] Includes curbing, flagging, rip-rap, rubble and others of minor importance.

TRAP ROCK.

New Jersey stood second among the States in the production of trap rock in 1910, 1911 and probably in 1912, California being second.

Of the stone quarried in the State in 1912, the trap rock was, as usual, the chief variety, constituting 69.16 per cent. The total value was $1,202,397, an increase over 1911 of $66,012. Of the total output $1,148,394, or 85.63 per cent., was crushed stone, $616,674 being for road metal, $189,641 for railroad ballast and $342,079 for concrete. As in 1911, there was a decrease in the amount used for road metal and an increase in the amount used for concrete.

The details regarding the production of trap rock are given in the following table:

PRODUCTION OF TRAP ROCK, 1912.

	No. of Producers.	*Amount Short Tons.*	*Value.*	*Average Price Per Unit.*	*Increase or Decrease.*
Building stone, rough and dressed,	10	....	$9,213	......	$3,059 I
Paving blocks,	7	(1,015,841 M)	31,646	$31.40	5,205 I
Rubble,	3	....	1,197	......	3,882 D
Rip-rap,	6	....	3,160	......	......
Crushed stone—					
Road metal,	51	770,578	616,674	.80	29,535 D
R. R. ballast,	11	272,406	189,641	.69	12,622 I
Concrete,	31	434,420	342,079	.78	70,876 I
Other values,	3	....	8,787	......	......
Total, 1912,	56	1,477,404[1]	$1,202,397	......	$66,012 I
Total, 1911,			1,136,385		

LIMESTONE.

The limestone statistics do not include the amounts nor value of stone used in the manufacture of lime or of Portland cement, this portion of the production being included in the value of those manufactured products.

The total value of the limestone quarried for other uses was $205,334, an increase of $67,186 compared to 1910. This increase was chiefly in stone for flux, the value of which showed a

[1] Total of crushed rock only.

$31,162 increase, not sufficient, however, to offset the very large decrease (over $100,000) of the previous year.

PRODUCTION OF LIMESTONE IN 1912.

Uses.	*No. of Producers.*	*Short Tons.*	*Value.*
Road making,	4	30,113	$19,509
Concrete,	4	16,180	9,014
Blast furnace flux,	12	230,822	122,943
Agricultural,	3	......	24,329
Other uses,[1]	5	......	29,539
Total,	15	......	$205,334

The two leading counties were Sussex, $146,117, and Warren, $31,988; Hunterdon and Somerset together produced $21,196, The chief centres in Sussex County were McAfee and Ogdensburg, and Buttzville in Warren County.

SANDSTONE.

Sandstone was reported from seventeen producers in five counties, the total value being $166,583, a gain of $10,818 as compared with 1911.

The different uses, value of stone and number of producers is shown in the following table:

PRODUCTION OF SANDSTONE IN 1912.

	No. of Producers.	*Value.*
Building stone, rough,	13	$55,609
Building stone, dressed,	5	49,665
Concrete,	3	37,529
Road metal, Rubble, Rip-rap,	5	11,676
Flagging, Paving, Curbing,	3	9,045
Other uses,	4	3,059
Total,	17	$166,583

There was a decrease in the output of road metal; but an increase in the amount of crushed stone for concrete as compared with 1911.

[1] Includes limestone for building, railroad ballast and other purposes of minor importance, here grouped together to conceal the output of individual operators.

Bergen County led in 1912 in the quarrying of sandstone, with value of $67,320, displacing Mercer County, which was second, value $52,689; Hunterdon, Essex and Somerset counties follow in the order named with total value of $46,574. Most of the stone from Mercer County was rough building stone, while in Bergen most of the product was dressed building stone. The larger part of the crushed stone for concrete was produced in Hunterdon County.

Practically all of the sandstone quarried was from the Triassic formations. Included under the heading of sandstone is some bluestone, and some argillite. The increased use of the dark argillite as a building stone is a new development in this industry. In building, the joint surfaces are made the exposed surfaces, some of them being dark and others, owing to a coating of silica, light. The handsome Cleveland Tower and large group of graduate school buildings at Princeton University are being constructed of this argillite in the manner described.

GRANITE.

Granite and granite-gneiss were quarried by 25 producers located in Passaic, Morris and Sussex counties. The total value was $142,515, as against $162,112 for 1911, a decrease of $24,597. Details are shown in the following table:

PRODUCTION OF GRANITE IN 1912.

	No. of Producers.	*Value 1912.*
Sold rough—building,	5	$25,880
Sold rough—monumental,	2	
Sold rough—other uses,	1	16,050
Dressed—building,	2	
Rubble,	2	2,495
Rip-rap,	3	
Crushed stone—		
Road making,	2	90,670
Railroad ballast,	3	
Concrete,	5	6,520
Other uses,	..	900
Total,	25	$142,515

Passaic County led in the production, its value being $71,343, although it had fewer producers than Morris, which was second and not far behind.

There was a decrease in the output of crushed stone and a notable increase in the production of building stone.

SLATE, TALC AND SOAPSTONE.

The combined value of slate, talc and soapstone for 1911 was $21,644, a decrease of $4,830. As there were less than three active producers in each of these industries, the values are combined in order that the figures of individual producers may not appear.

The two active slate properties are at Lafayette and Newton, both in Sussex County, and both producing roofing slate.

The single producer of talc and soapstone is located just north of Phillipsburg, in Warren County. The product is sold partly in the crude form and partly ground into "mineral pulp," which is then sold and used for various purposes.

SPECIAL STATISTICS REGARDING THE STONE INDUSTRIES IN NEW JERSEY IN 1909.[1]

	Trap Rock.	*Sand-stone.*	*Lime-stone.*	*Granite.*	*Total.*
No. of operators,	55	15	6	6	82
No. of quarries,	58	16	6	6	86
Capital,	$870,955	$176,285	$73,489	$31,479	$1,152,208
Expenses of operation and development,	$1,048,945	$143,458	$163,877	$52,371	$1,408,651
This is distributed as follows:					
Services—					
Salaried officers and clerks	58,446	8,540	8,470	1,227	76,683
Wage earners,	591,476	93,291	115,384	39,343	839,494
Miscellaneous—					
Supplies,	156,565	17,973	25,902	8,491	208,931
Fuel and rent of power,	54,700	4,704	2,037	2,161	63,602
Royalties and rent of mines,	36,830	1,900	6,109	120	44,959
Taxes,	5,172	1,237	189	34	6,632
Contract work,	29,550	820	....	....	30,370
Rent of offices and other sundry expenses,	116,206	14,993	5,786	995	137,980
Value of products,	$1,166,345	$187,272	$180,604	$60,174	$1,594,395

Persons engaged in industry,	1,722	240	451	122	2,535
Proprietors and salaried officers, and clerks,	114	32	14	8	168
Wage-earners (Dec. 15, 1909, or nearest representative day),	1,608	208	437	114	2,367
Land controlled, acres,	1,449	247	662	156	2,514
Owned,	845	244	109	91	1,289
Held under lease,	604	3	553	65	1,225
Primary horse-power,	5,348	694	565	215	6,822

[1] Modified from the table published in 13th Census of the United States, Supplement for New Jersey, published in 1913.

STARTING A NEW QUARRY.

There are doubtless still many deposits of good stone of various kinds in New Jersey yet undeveloped. Many owners hesitate to undertake the opening up of their deposits because they do not know just how to go about it. Of course, in the development of such properties many things have to be taken into consideration, which determine success or failure. Among these are the quantity and quality of the stone, the demand and available supply of the kind of stone involved, the nearness of the deposit to transportation routes and to good markets, ease and facilities of quarrying, financing the proposition, etc., etc. The quality of stone is only partially determinable by a hand specimen; it is necessary to open up the quarry to a certain extent before one can speak positively regarding quality. Sometimes the rock proves to be so broken up by joint cracks that large blocks cannot be quarried, and it can only be used for rough work or for crushed stone. There are certain defects affecting different kinds of stone for different purposes whose presence or absence can hardly be determined until the quarry has been at least partially opened up. For example, in the case of granite there may be large areas spoiled by the presence of black mica or biotite balls, or by wavy streaks of alternating dark and light-colored rock. The demand for a particular kind of stone may be affected by changes in public taste, a notable case of this kind being evident

in the decreased demand for brown sandstone in recent years. On this Dr. J. Volney Lewis says:[1]

"In the brownstone regions, the larger quarries that once supplied the stone for numerous buildings in all the larger cities of the east are now closed and their machinery is rusting away. Some of these, as in the city of Newark, have become more valuable for building space and are now overrun by the growth of the city; but this is not the case with the great Belleville quarries, and there are many places in the surrounding country that could supply this stone in vast quantities. Public taste has changed. Brownstone houses and brownstone 'fronts' are no longer fashionable. The colors are too somber to suit the popular taste for residences, and are not adapted to the prevailing styles of architecture. Fewer large buildings of a public or a semi-public character are constructed of it, and even the churches are adopting the lighter tints."

E. R. Buckley looks for a change in taste to occur again. He says:

"The market value of a stone is often influenced by its color, without regard to its strength and durability. The market value of stone, as well as other products, is controlled by the law of supply and demand. The supply of a certain kind of stone may remain constant, but the demand for that stone may fluctuate on account of fashion. In stone, color, as a rule, is the only element which is subject to the influence of fashion. Until a few years ago brown stone was all the rage, both for business blocks and residences, but the eye became weary of gazing at long rows or somber-colored buildings, and the fashion changed to light-colored stone, where it now rests, awaiting the next reversal. Immense quantities of light-colored stone are now being used, but its prestige is only temporary. The tide will swing back again in a few years, and it is to be hoped that the halt will be made at a place where the use of neither dark nor light-colored stone will be supreme. A judicious use of both will serve to relieve the monotony occasioned by long rows of somber brownstone buildings or the dazzling glare of white limestone and marble."

Ease of quarrying frequently affects the cost of getting out stone considerably. One of the largest granite quarries in the South, which the writer has visited several times, consists of a large hill of the finest monumental granite, uniform in texture and color, with only a few joint cracks, without any soil cover, practically free of weathered rock and with a fine rift which has been developed by a lift parallel to the surface of the hill. All that is necessary in quarrying is to split off great blocks, let them slide part way down hill, then split them up into pieces of any size desired, and load by derrick onto the flat cars awaiting a few feet below. What a contrast this presents to those quarries

[1] Building Stones of New Jersey, An. Rept. State Geologist for 1908, p. 58.
[2] Building and Ornamental Stones of Wisconsin, p. 14.

where the blocks have to be hoisted from pits 200 and 300 feet deep!

The financial side of developing a new quarry is, of course, of the greatest importance. No matter how large and how good a deposit of stone there may be, nor how favorably situated for working, the whole proposition may easily prove a failure by reason of poor financial methods. In this connection we quote certain paragraphs from an article by Mr. George Barnum, in *Stone* for April, 1913, which contain some valuable advice to those having in mind the "Starting of a New Quarry":

"If a stone property is to be exploited, the raising of money is, of course, the first essential. Even a small quarry with a modest equipment cannot be opened without the expenditure of a considerable sum. The stripping, even if it be all soil, is expensive, and if several layers of waste stone have to be removed, the cost may be quadrupled. The development of a quarry face takes time, and time is money, besides which there may be considerable wild rock to be disposed of. Then there are the provisions that must be made for the shipping out of the stone, whether it be by rail or over wagon roads. The equipment is entirely problematical, depending upon the nature of the stone and the amount that is to be quarried.

"Having decided to develop a stone property, the raising of the necessary money becomes the first consideration. Just here is where a mistake is usually made. Perhaps the man who is making the venture has availed himself of so-called 'expert' advice. It is reasonably certain that this advice will not be along the line of modest, conservative, gradual growth. The expert jumps at once the preliminary stages, and has in mind the active quarry with an output of thousands of feet a month. The equipment he suggests is along this line, and it is safe to say that there will be no actual need for much of the machinery he recommends for fully a year's time. * * * How often it has happened that a new man in the stone industry has spent all of his money and secured a splendid equipment before his quarry was half ready to begin production. * * *

"There is sometimes a more sinister manifestation which has the same effect: A company which is the sport of promoters may install an equipment of the most elaborate character, and entirely beyond any real needs of the quarry for months or years to come. This is done to 'make a showing,' to impress the public so that it may be possible to sell more stock or float a new bond issue. * * *

"One of the shrewedest stone men I have ever known, and one who has had experience in widely different fields, and always with success, told me that the policy always followed by himself and his associates was that 'a quarry must always pay its own way.' This cannot be taken with absolute literalness, for, as I have said above, there is much preliminary work that must be paid for in advance of production. What he meant was that he never assumed before it was demonstrated that any quarry was to be a great big paying venture. In other words, he always began modestly, not from any lack of abundant means, but from a wise conservatism. The quarry would be opened in a small way, with the least possible equipment. When the ledges of stone proved their worth, every cent of income was turned back into development. Of course, there soon came a time when it would be shown that a quarry was to be a great money-maker, and then all the resources of this man and his associates were available to make the most of the opportunity. In this way, and through this intelligent effort, have grown up some of the greatest quarries in this country.

"The great trouble with most new ventures in the stone industry is that those in charge of the enterprise are not willing to begin in a sufficiently modest way. Perhaps they have no money in hand themselves, and, finding that they must raise capital for operations, they think it would not pay to 'make two bites at a cherry,' and so they seek to get all the money needed for one or two years' operations, or sufficient to put the quarry on a paying basis. The weakness in this course is that at this stage of the game the promoters have nothing to show save unworked ledges of stone, and they must pay big premiums and make large sacrifices in order to secure funds. If it is worked as a straight business proposition, it will be found that capitalists are not fond of giving their money for a minority interest in any enterprise. The man who yields control of his business in exchange for the money to carry it along is never in a very happy position. If the matter is put in the hands of the professional promoters, as is too often done, it will be found that such an enormous commission must be paid that success is well nigh impossible. I know of one stone company, capitalized for a very large amount, where one dollar out of every three that was raised went to the promoters. What chance was there for the paying of dividends when so large a proportion of the capital stock was diverted from its legitimate purpose? It is the carrying of burdens of this kind, on indebtedness representing no productive power, that has brought so many stone companies to bankruptcy.

"It is impossible to deny that a few companies that have started in this way, with a liberal sale of stock and bonds, have achieved a success, although by far the larger proportion of them have failed and passed into other hands. As a rule, those which have steadily and surely made their way to prosperity have gone about it in other ways. There has been a modest capitalization at the outset with the sale of stock among those who were locally interested in the success of their scheme. The money in hand was intelligently used for the development of some sort of a quarry face. The least equipment that could possibly suffice was installed. Stone was gotten out and sold. Often it was hauled for miles by teams before it could find rail shipment. The main effort was not to show profit in operation, because the method of extraction might be crude and the expenses of handling excessive. The work that was done served to demonstrate the quantity, quality and availability of the stone and that there was a market for it. With these facts at hand the raising of money to carry along the work on a much more extensive scale becomes greatly simplified. Local capital may be very timid as far as an entirely new enterprise is concerned, but it will readily respond where the question is one of building up an industry already on a sound footing, even if it be a small one for the moment. Pay rolls and supplies play a prominent part, and the local banks will generally be found willing to lend a hand. I personally know of a number of quarries that have started out in this conservative way and have put themselves on a paying basis in an almost incredibly short space of time."

SAND AND GRAVEL.

The total production of sand and gravel in New Jersey in 1912 was 3,245,767 short tons, valued at $1,146,640, an increase of $87,714. The details regarding the production are given in the following tables:

SAND AND GRAVEL MINED IN 1912.

Variety.	No. of Producers.	Amt. in Short Tons.	Value.
Moulding sand,	39	459,397	$279,948
Glass sand,	8	102,782	70,027
Building sand,	45	1,425,861	316,435
Grinding and polishing sand,	5	95,690	47,854
Fire sand,	11	105,843	97,841
Engine sand,	4	55,344	22,077
Paving sand,	6	168,233	35,883
Other sands,	9	55,706	47,218
Gravel,	36	776,911	220,357
Total,	95	3,245,767	$1,146,640

PRODUCTION OF SAND AND GRAVEL BY COUNTIES, 1912.

County.	No. of Producers.	Amt. in Short Tons.	Value.
Burlington,	21	1,584,343	$362,074
Middlesex,	17	493,611	245,108
Cumberland,	10	386,504	213,896
Cape May,	3	190,076	87,130
Morris,	6	183,668	62,433
All others,[1]	38	407,565	175,999
Total,	95	3,245,767	$1,146,640

Glass sand is produced chiefly in Cumberland County, with Gloucester second. Cumberland also leads in the production of moulding sand, with Middlesex second. Burlington stands first in the production of grinding and polishing sand, Cumberland being second. The fire sand is chiefly obtained in Middlesex County, Morris standing second. Middlesex leads in the production of engine sand and paving sand, while Burlington is second in both cases. In the production of gravel Burlington stands first, while Monmouth is second.

PORTLAND CEMENT.

The recent growth of the American Portland cement industry has been so rapid that its present relative standing among our great industries is realized by few, even of those directly inter-

[1] Includes Monmouth, Camden, Gloucester, Warren, Bergen, Ocean, Union, Atlantic, Sussex, Passaic and Mercer in the order given. It is not feasible to give the individual figures in these cases.

ested. Its importance, both commercially and financially, is perhaps best brought out by comparison with the American iron industry, whose standing is everywhere fully understood. The following table, compiled by E. C. Eckel, of the United States Geological Survey, gives the output of pig iron and Portland cement in long tons during every fifth year from 1880 to 1910, inclusive.

COMPARATIVE GROWTH OF CEMENT AND IRON INDUSTRIES.

Year.	*Pig Iron Long Tons.*	*Portland Cement, Long Tons.*	*Percentage of cement to Pig Iron.*
1880,	7,749,233	7,000	0.1
1885,	7,415,469	25,000	.3
1890,	9,202,703	56,000	.6
1895,	9,446,308	165,000	1.7
1900,	13,789,242	1,414,000	10.3
1905,	22,992,380	5,874,469	24.3
1910,	26,674,123	12,986,152	48.7

The production of Portland cement in 1912 in the United States was 82,438,096 barrels. The production of the leading States was as follows:

PRODUCTION OF PORTLAND CEMENT BY STATES, 1912.[1]

State.	*No. of Producing Plants.*	*Quantity in Barrels.*
Pennsylvania,	23	26,441,338
Indiana,	5	9,924,124
California,	8	5,974,299
New York,	7	4,492,806
Missouri,	5	4,355,741
Illinois,	5	4,299,357
New Jersey,	3	4,246,803
Michigan,	10	3,494,621
Iowa,	3	3,228,192
Kansas,	10	3,225,040
Total (ten States),		69,682,321
Total (other States),[2]		12,755,775
Total, United States,		82,438,096

[1] From advanced chapter of Mineral Resources of the United States for 1912.
[2] Includes the fourteen additional States reporting.

The shipments of the ten leading States was as follows:

SHIPMENTS OF PORTLAND CEMENT BY STATES, 1912.[1]

State.	Shipping Plants.	Quantity (Barrels).	Value.	Average price per Barrel.
Pennsylvania,	26	27,539,076	$18,918,165	$0.687
Indiana,	5	9,634,582	7,237,591	.751
California,	8	6,093,790	8,215,894	1.348
Missouri,	5	4,614,547	3,700,776	.802
Illinois,	5	4,602,617	3,444,085	.748
New York,	7	4,543,060	3,448,735	.759
New Jersey,	3	4,490,645	3,052,098	.680
Michigan,	10	3,651,094	3,145,001	.861
Kansas,	12	3,592,148	2,815,113	.784
Iowa,	3	3,190,354	2,790,396	.875
Total (ten States),		71,951,913	$56,767,854	
Total (other States),[2]		13,060,643	12,341,946	
Total, United States,		85,012,556	$69,109,800	

From the above tables it is evident that New Jersey occupies a creditable position among the cement producing States, being among the ten which produced about 85 per cent. of the total, and standing seventh among these ten. The total production of New Jersey in 1912 was 4,246,803 barrels. This was 165,087 barrels less than the amount produced in 1911, involving a decrease in value of $112,259. The whole Lehigh district, of which New Jersey is regarded as a part, reported a decreased production in 1912, which "was probably due in large measure to an overproduction in 1910 and to the building of many mills in other parts of the United States, which have restricted the trade territory of the Lehigh district."[1]

This year, in addition to the production, the shipments of Portland cement can be furnished for the first time. The total shipments in New Jersey in 1912 were 4,490,645 barrels, valued at $3,052,098. The average price per barrel was $0.68, as against $0.738 in 1911. At the close of the year the stock on hand amounted to 231,398 barrels.

[1] From advanced chapter of Mineral Resources of the United States for 1912.
[2] Includes the fourteen additional States reporting.
[1] According to E. A. Burchard, in advanced chapter from the Mineral Resources of the United States for 1912.

As during the previous year, there were three active plants, all located in Warren County, and all making use of limestone and cement rock as raw materials.

LIME.

The stone used in making lime is not included in the statistics of limestone in the stone industry, as to do so would result in a duplication of values.

The production of lime in 1912 amounted to 16,538 short tons, valued at $65,241, which is a decrease of 10,519 tons and $48,543 in value, a larger decrease than that of the previous year. The average value per ton in 1911 was $3.94 per ton as against $4.20 in 1911. There were 19 active producers, most of them burning the blue magnesian limestone. Four firms, however, use the white crystalline limestone and manufacture the larger part of the output.

The chief facts regarding the industry are tabulated as follows:

PRODUCTION OF LIME IN 1912.

Uses.	*No. of Producers.*	*Amount. Short Tons.*	*Value.*	*Value Per Ton.*
Building lime,	4	229	$1,102	....
Chemical works,	1			
Paper mills,	2	6,921	37,831	....
Dealers,	1			
Fertilizer,	15	9,388	26,308	....
Total,	19	16,538	$65,241	$3.94

Sussex County was first; Warren, second; Hunterdon, third; Somerset, fourth, and Morris, fifth.

Most of the lime made in New Jersey in 1912 was for use as a fertilizer.

SAND-LIME BRICK.

As in 1911, only two counties produced sand-lime brick, Camden and Morris. An additional plant was started in Camden County, making three in that county which, with the one in

Morris, makes four plants in operation. Despite this increase in the number of plants, however, there was a decrease in the total value of the production of $10,786, or 60.9 per cent. The total production for 1912 was 961 thousand, with a value of $6,924. In 1911 the production was 1,988 thousand, with a value of $17,710.

The New Jersey figures do not appear to reflect the general conditions in this industry. According to recently published figures of the United States Geological Survey, "the value of the product of the United States reported in 1912 was $1,170,-884, compared with $897,664 in 1911, an increase of $273,220, or 30.44 per cent."[1]

The authority just quoted makes the following interesting general statement regarding the history and conditions of the sand-lime industry:

"The sand-lime brick industry has been established in the United States a little over 10 years, and in Europe, especially in Germany, where it is a large and flourishing industry, for a much longer period. In this country it has passed through many vicissitudes. At first it grew rapidly, rising from 1 plant in 1901 to 16 in 1903 and to 57 in 1904, and in 1907, 94 plants were in active operation, reporting products valued at $1,225,769. This growth was not, however, a healthy one. Many plants were erected where market conditions were not propitious and others where suitable materials were not available; others, although conditions and materials were satisfactory, failed for want of technical skill or because of poor management. Consequently many plants that were erected in the beginning of the industry are not now operating, and some of them never even began operations. Notwithstanding this serious handicap and the fact that the value of the product decreased almost constantly from 1907 to 1911, in 1912 the number of plants in operation increased and the value of the product showed a large gain. During 1912 some of the abandoned plants were taken over by skilled men, were remodeled in accordance with the latest developments, and are now being operated successfully. The prospects for 1913 are bright, the future of the industry seems established, and a steady growth may be expected. There appears to be a successful field for the sand-lime brick industry, especially where other building materials are scarce and sand is plentiful and lime accessible. The product, as shown by experience at home and abroad, may be made durable and attractive, and tests made on it show that it meets all requirements as a building material."[1]

The leading State in the production of sand-lime brick is Michigan, which had 10 operating plants reporting in 1912, and

[1] Advance chapter, "Mineral Resources of the United States for 1912."

made 32,889 thousand common brick and 2,726 thousand front brick, the total value of which was $210,000.

MINERAL WATERS.

There was a fair increase in quantity but a slight decrease in value in the mineral water production of New Jersey in 1912, as compared with 1911. The quantity in 1912 was 2,386,217 gallons, valued at $209,726; while in 1911 the quantity was 2,233,627 gallons, valued at $210,123. The increase in quantity was 152,590 gallons, while the decrease in value was only $397. The average price per gallon received in 1912 was 8.8 cents; while in 1911 it was 9.4 cents.

On the basis of use, the total value for 1912 is made up of $2,150 for medicinal water and $207,576 for table water. There was also 44,600 gallons used in the manufacture of soft drinks, the value of which is not included in the totals here given.

Twelve springs reported sales in 1912, of which 4 were in Bergen County, 3 in Somerset, and one each in Camden, Morris, Mercer, Monmouth and Union.

GREENSAND MARL.

Only four producers, all in Burlington County, reported a production of greensand marl in 1912, their total being only 915 tons, valued at $229. As even this output was chiefly used by the owners of the pits, the value represents hardly more than the cost of digging. This industry, which, thirty or forty years ago was one of the most important mineral industries of New Jersey, has gradually declined until it has practically ceased to exist. In some respects this is unfortunate for the agricultural interests of the State, as it has been clearly demonstrated that many of the most fertile and productive farms now under cultivation owe their fertility largely to their having been marled many years ago.

Greensand marl is a slow fertilizer, requiring years to yield its beneficial constitutents to the soil. The chief of these con-

stituents is potash, though in a less degree calcium phosphate and calcium carbonate are also gradually yielded to the soils on which the marl has been spread. The potash comes from the mineral glauconite, the dark, olive-green mineral which forms the distinguishing constitutents of the marl, the calcium phosphate comes chiefly from the fragments of the bones of prehistoric vertebrate animals scattered through the beds and the calcium carbonate is derived from the disintegrating shells of the fossil mollusks which often occur in considerable abundance in the marl. The chief reasons for the decrease in the use of marl are probably the labor attached to digging it and its slow action, as compared with the easily obtained and quick acting commercial fertilizers. During work in the field the writer has frequently advised farmers owning marl beds to use it on certain fields which are allowed to lie fallow while other parts of the farm are treated with commercial fertilizers; or to use it on land under cultivation in addition to the commercial fertilizers, going ahead as if the marl had not been used and counting on its benefiting the land in years to come instead of during the present season.

MINERAL PAINTS.

The mineral paint industry includes natural pigments, pigments made directly from ores and chemically manufactured pigments. Shale is ground and made into a pigment at one plant in Middlesex County. Zinc oxide is usually made at Newark, by the New Jersey Zinc Company, directly from the zinc ore mined at Franklin Furnace, but this company reports no output in 1912.

Most of the mineral paints made in New Jersey in 1912 were of the chemically manufactured type. Of these the principal one was lithopone, which was made by three producers, one in Camden County, one in Essex County and one in Union County. The combined production of these producers in 1912 was 12,743 short tons, valued at $905,543. This is more than the whole amount made in the United States in 1910 and only 4,123 tons

less than the whole amount for 1911. The use of lithopone is increasing, and in view of the fact that New Jersey is one of the leading, if not the leading producer, the following details regarding it may be of interest:

"Lithopone, a very white pigment, is precipitated by the double decomposition of zinc sulphate and barium sulphide, thereby forming an intimate mixture of zinc sulphide and barium sulphate. The peculiar property which it possesses, of darkening under the actinic rays of the sun, makes it essential that it be combined with other more stable pigments to prolong its life when exposed to weather. Lithopone contains approximately 70 per cent. barium sulphate, 25 to 28 per cent. zinc sulphide, and as high as 5 per cent. of zinc oxide. Its specific gravity is about 4.25. It is excellently suited for interior use in the manufacture of enamels and wall finishes. When properly mixed with other pigments, such as zinc oxide and calcium carbonate, fair results are obtained as a pigment for outside work. Lead pigments are never used with lithopone, as lead sulphide results, giving a black appearance. The characteristic flocculent, non-crystalline appearance is plainly evident when examined under the microscope."[1]

In addition to lithopone, red lead, litharge and white lead were made in Essex County.

The total for mineral paints is combined with that of coke and its by-products, in order to conceal the production of individual operators; the combined total for 1912 being $2,812,424.

COKE.

Coke, with its by-products, tar, liquid ammonia and gas (illuminating and fuel), was manufactured at Camden. Since there was only one producer, separate quantities and values cannot be given and the total value of the coke and its by-products produced has been combined with that of mineral paints. In 1912 the combined total amounted to $2,812,424.

GEMS.

It is not generally known that a small quantity of minerals are found each year in New Jersey which are cut and used as gems. In 1912 the total value of such minerals was $225. This included quartz pebbles used for jewelry.

[1] Bull. Sci. Sec. Paint Mnfrs. Assoc. W. S. No. 29, 1910, p. 10, quoted in Min. Res. of W. S. for 1911.